POWER PLANT ENGINEERING

Established Over 35 Years

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EDITORIAL STAFF — ARTHUR L. RICE, Editor; R. E. TURNER, Managing Editor; A. W. KRAMER, Associate Editor; CHESTER R. EARLE, Associate Editor; RICHARD H. MORRIS, Associate Editor

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Rhapsody in Steel

IT IS NOT often that an opportunity arises whereby we are enabled to enliven these pages with an example of feminine charm such as you see portrayed here, consequently when such an opportunity does present itself we are too human to resist it. So here we have a young lady playing the or—but no, she is not playing the organ; indeed it's not a musical instrument at all. She is merely operating the control for a reversing rolling mill used in the steel industry. Now, please don't ask us where the rolling mill is. We don't know—maybe it is behind that curtain or perhaps it exists only in the young lady's imagination; anyway, why worry about it? Here is the girl; why bother about the mill?

A funny rolling mill control? Well, rather. But the General Electric Co. engineers who designed it find that it has many advantages over the conventional type of control board. By means of this "piano" type keyboard one person can easily control a large number of auxiliary mill drives. And, by means of the easily manipulated foot pedals, two large motors totalling 10,000 hp. are brought from full speed in one direction to full speed in the other direction in two seconds.

Whether or not the young lady goes with the keyboard we do not know but, if she does, we hope they will find some use for this type control in the power plant. Our staff is hard at work trying to find an application. Until we do, however, our esthetic tendencies will have to find satisfaction in making plants architecturally attractive as described on p. 464.

Plate Glass Windows Display Ice Manufacture

NEW 205-T. PLANT OF THE PEORIA SERVICE CO. MAKES ICE IN PLAIN VIEW OF THE PUBLIC. THREE 10 BY 20-IN. HORIZONTAL DUPLEX COMPRESSORS DRIVEN BY SYNCHRONOUS MOTORS SUPPLY REFRIGERATION IN A PLANT WHICH MAY WELL BE USED AS A MODEL BY THE INDUSTRY

INNATE CURIOSITY of the human being and the fascination, for the average person, of moving machinery has been utilized in a striking manner by the Peoria Service Co., Peoria, Ill., to familiarize the general public with the purity, careful manufacturing methods and advantages of manufactured ice made in a modern plant.

This company, the largest ice manufacturing unit of the Federal Public Service Corp., Chicago, Ill., supplies ice to Peoria and to a number of smaller towns within a radius of 50 mi. Of the company's three ice plants, Plant No. 2, recently rebuilt on the site of an old steam-driven plant, is the largest and most important as well as being a decided innovation in ice plant design.

Instead of hiding the plant on a back street, it is located on one of the main business streets, South Adams, not far from the active business district and instead of hiding the machinery behind brick walls, it is installed immediately behind seven plate glass windows, with the machinery floor and ice tanks on the street level so that the entire operation of ice making is in plain view of the passerby.

In keeping with the prominent location of the plant, the building itself is of buff face brick with red brick and red tile trim. Business offices of the company are on the second floor reached by a stairway leading up through the machinery room so that each visitor has a complete and unobstructed view of the entire plant. Machines are painted green with the concrete floor and wooden tank tops red, showing in pleasing contrast with the light brick walls and white covered or frosted piping. Ample skylights furnish ventilation necessary for keeping the tank tops dry. In winter the ice plant is heated by three gas-fired unit heaters.

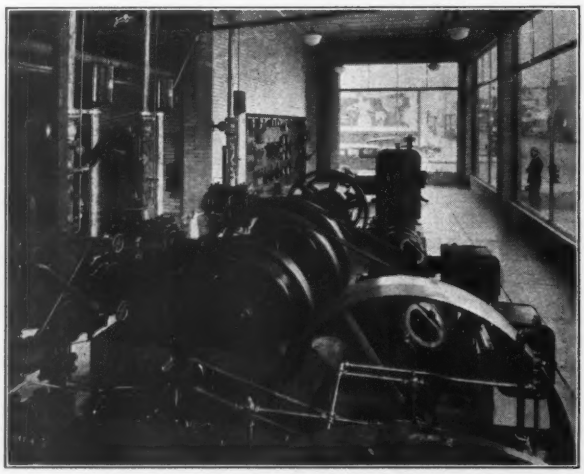


FIG. 1. AIR COMPRESSORS AND SWITCHBOARD

As might be expected in a plant so prominently located, no detail was overlooked in an effort to make this the finest and most attractive ice plant in the middle west. Operating results for the short time that the plant has been in operation confirm the judgment of the designers as to its economy while the attractiveness and accessibility of the plant are important factors in maintaining proper public relations and meeting competition of the mechanical refrigerator.

ULTIMATE CAPACITY 300 T.

At present the normal capacity, using 15 deg. F. brine, is 200 t. per day from two 924-can ice tanks with refrigeration supplied by three 10 by 20-in. Vilter horizontal duplex motor-driven compressors. Four horizontal multipass condensers are arranged one above the other against one wall. Space has been provided in the building for a third tank and fourth compressor which will increase the total capacity to 300 t. Ice storage in three rooms approximates 3000 t. High pressure air for agitation is supplied by three 10 by 8-in. horizontal compressors and refrigeration for a 6-room cold storage across the street supplied by a 9.5 by 9.5-in. Vilter compressor.

General arrangement of the plant is shown by the plan and section Fig. 2. The ammonia and air compressors are located along the front of the building immediately in front of the plate glass windows with the 11 panel Westinghouse switchboard located in one corner immediately behind the space allowed for the engineer's desk and a small refrigeration exhibit.

Immediately behind the switchboard is a small compartment in which are located the four condensers, ammonia receivers, air cooler, dip water heater, dehumidifiers, core water cooler and water treating tank. The water treating tank extends down into the basement. Here are located two pressure type sand filters, sweet water pumps and brine pumps. Treated water from the pumps were left over from the old plant. Refrigeration for this purpose is supplied by a 9.5 by 9.5-in. Vilter compressor driven by a Westinghouse 50-hp., 2200-v., unity power factor synchronous motor at 240 r.p.m. The rooms are kept at from 31.5 to 33 deg. F. and the compressor is operated intermittently so as to keep the brine temperature at from 10 to 25 deg. F.

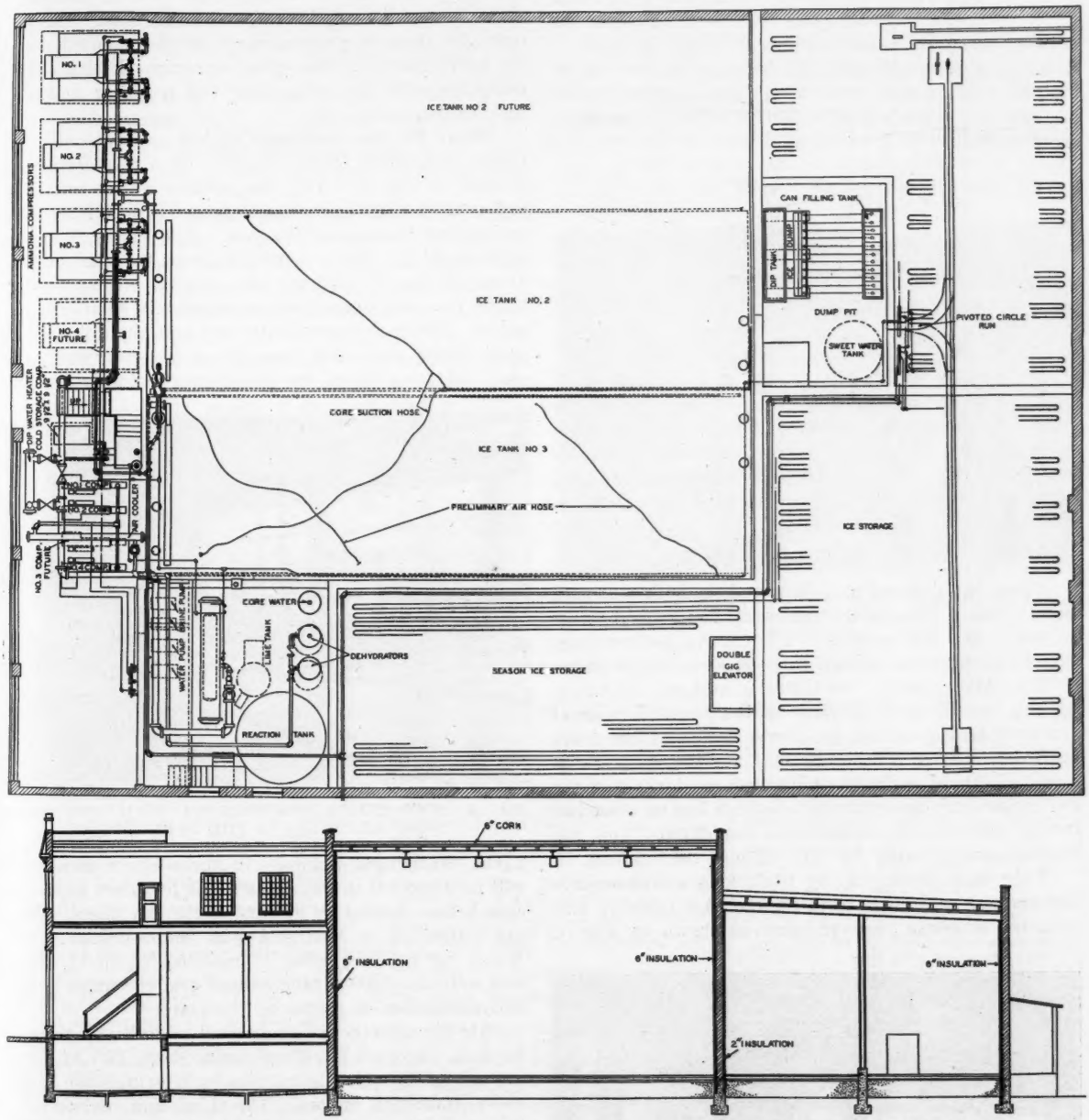


FIG. 2. GENERAL CROSS-SECTION AND GENERAL PLAN OF THE PEORIA SERVICE CO. PLANT NO. 2

filters flows into a small float controlled tank from which the sweet water pumps take their suction. These pumps are controlled by a float in the 5000-gal. tank above the can filler. The brine pumps circulate brine from the ice tank through the core water cooler.

In another basement are located a 1350-g.p.m. Pomona deep well pump and a 35-t. brine cooler used for the six-room storage warehouse across the street. This cooler and the two 250-g.p.m. motor-driven brine

Lockers, wash basins, toilets and a Bryant gas-fired furnace for heating the second floor offices are located in the basement underneath the switchboard. Two day storages and one season storage complete the building.

The large 10 by 20-in. duplex compressors are each driven by Westinghouse 175-hp., 2200-v. unity power factor 150-r.p.m. synchronous motors. One of them is equipped with clearance pocket control to reduce the capacity of the machine 1/6, 1/3 or ½ as desired. Each

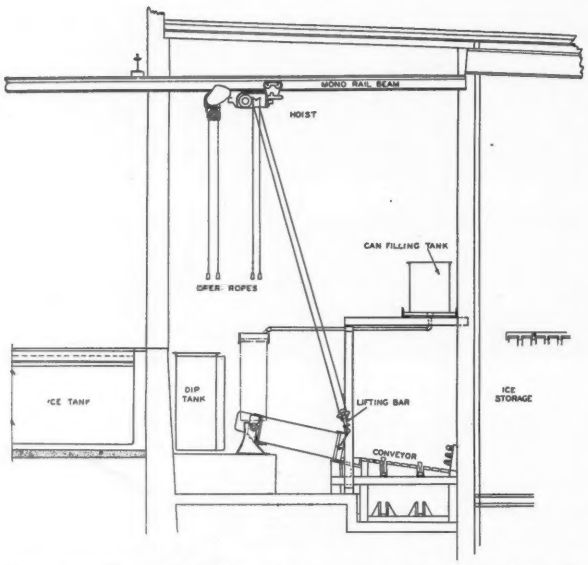


FIG. 3. ARRANGEMENT OF THE DIP TANK AND DUMP RACK

machine has its own motor-driven exciter, two of the units, No. 1 and No. 2, have 12.5-kw. exciters, large enough to excite two of the motors, but No. 3 has a 5¾-kw. exciter large enough for one machine. The cold storage compressor motor is also provided with a 5¾-kw. exciter.

All Motors 2300 and 440 V.

Power is purchased at 2300 v. and the bulk of it used at this voltage. Auxiliary and pump motors all operate on 440 v. and the lighting is 110 v.; this lower-voltage current is supplied through three 75-kv-a., single-phase, 2300 to 440-v. power transformers and one 37.5-kv-a. lighting transformer. Because of the preponderance of synchronous motor load, the power factor seldom drops below 99, making a desirable load for the electric system. Electrical connections between machines and the switchboard are made through conduits laid on a conduit trench between the compressor foundations and the windows and running the full width of the building.

Four large 36-in. dia. by 18-ft. long multipass condensers are used in a bank on the high-pressure side with the ammonia receiver below as shown by Fig. 7.

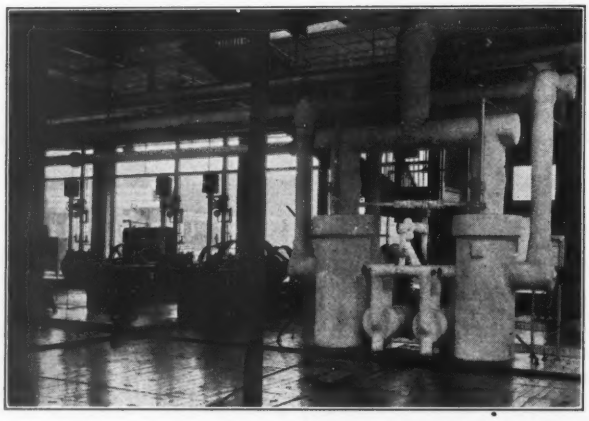


FIG. 4. ACCUMULATORS AND FLOAT VALVES

These four units are mounted on a structural steel frame tight against the wall and make an unusually compact arrangement. They are piped so that any one can be bypassed or cut out as the load may require. The air cooler and dip tank water heater are located above the store room, shown at the right of the condenser. The large tank at the extreme left next to the rack of cans is the core water cooler. Immediately back of the cooler is the dehumidifier and water treatment tank. The picture also shows the arrangement of the monorail hoist for harvesting ice. The plant is equipped with a Hill noncondensable gas eliminator and a Vilter ammonia regenerator.

Water for the condensers, coolers and general plant service is pumped from a deepwell at a temperature of around 54 deg. F. This temperature varies but little and enables a head pressure of from 110 to 118 lb. to be maintained throughout the year. The suction pressure is about 23 lb. Water normally leaves the condenser at about 62 deg. F. and the part needed for ice making passes to a cold process water treater, the balance to the sewer. Water is treated with lime and alum, filtered in sand filters and then pumped to a sweetwater tank above the can fillers by one of two motor-driven, 40-

FIG. 5. THE THREE COMPRESSORS WITH THE BRINE TANK AGITATORS IN THE FOREGROUND

g.p.m. centrifugal pumps. In the summer this water will be precooled in the storage tank by direct expansion coils before flowing by gravity to the can fillers. Cores are pulled by a Viking 1½-in. motor-driven pump. Water for refilling cores is precooled by direct expansion coils in a 1200-g. tank located near the water treater and condensers as shown on the plan.

Air for agitation is compressed to 30 lb. by three 10 by 8-in. Ingersoll-Rand air compressors, two of which are driven through v-belt drives by Westinghouse 25-hp., 440-v. induction motors. The third unit, driven by a 35-hp. Continental gasoline engine through a Twin Disc clutch is used as a standby in case of failure of the power supply. Space is provided for a fourth unit to be added when the third tank is installed.

Leaving the compressors, the air passes through a multipass tubular cooler (supplied with cold water) an oil and moisture separator, a Cash regulating valve (where it is reduced to 18 lb. pressure) to two shell and coil type dehydrators. These dehydrators cooled by brine are used in series, the air and brine flowing of the second unit is removed by reversing the flow of gas

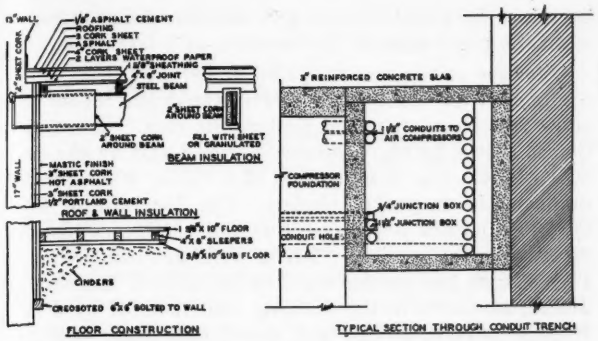


FIG. 6. DETAILS OF THE STORAGE ROOM WALL CONSTRUCTION AND THE CONDUIT TRENCH ARRANGEMENTS

and air every 8 hr. by means of a four-way valve which reverses the relative location of the two units. Cans, 11 by 22 by 64 in., are racked 11 to a grid and fitted with permanent air connections in the center of the bottom of the can. When filling, water is kept out of the permanent air lines in the can by connecting up a preliminary air hose which is left connected until the grid is in place in the brine tank. The regular rubber hose air connection to the header is then substituted quickly for the long preliminary connection.

Monorail Hoists Used for Harvesting Ice

Ice tanks are equipped with Vilter super-flooded boiler type evaporator coils with headers in the center of the tank, making the coils as short as possible so as to keep more liquid ammonia in the coils and permit a quicker gas return to the compressor. The big suction and liquid header connect into one large accumulator. In this accumulator is a spiral coil carrying the liquid ammonia which is cooled by the suction gas as it leaves the ice tank. Liquid supply to the ice tank coils is controlled by float valves which keep the coils flooded at all times.

Tanks are insulated with 6 in. of sheet cork on the bottom, 12 in. of granulated cork on the outside walls and 16 in. of granulated cork between tanks. Columns are insulated by 4 in. of sheet cork.

With 15 deg. F. brine the freezing time is from 42 to 43 hr. and ice is pulled regularly by two men per shift at the rate of 11 cakes about four times an hour. Record of the cakes pulled is kept on a log sheet by the men and a record of the time is made by a recording pressure gage, calibrated in ounces per square inch, which is connected to the can fillers. Every time the can filler is

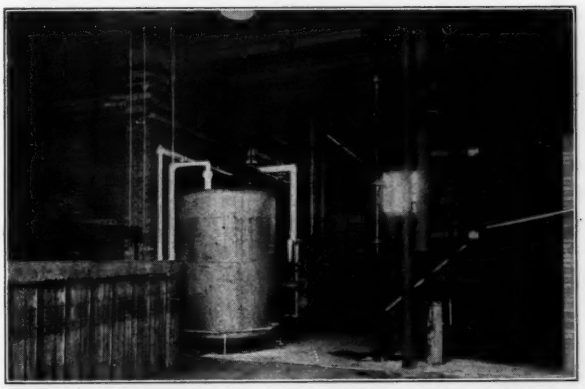


FIG. 7. ARRANGEMENT OF THE MULTIPASS CONDENSERS, WATER TREATER, DEHUMIDIFIERS AND CORE WATER PRECOOLER

Principal Equipment in Peoria Service Co., Ice Plant No. 2

3 The Vilter Mfg. Co., 10 by 20-in. horizontal duplex ammonia compressors driven by Westinghouse direct-connected, 175-hp., 2200-v., 3-phase, 60-cycle, unity power factor synchronous motors at 150 r.p.m. One machine with clearance pockets to reduce capacity 1/6, 1/3 or ½ as desired.

1 The Vilter Mfg. Co., 9½ by 9½-in. horizontal ammonia compressor driven by a Westinghouse direct-connected, 50-hp., 2200-v., 3-phase, 60-cycle unity power factor synchronous motor at 240 r.p.m.

3 Ingersoll-Rand Co., 10 by 8-in. horizontal air compressors delivering 30 lb. ga. air for agitation. Two of these machines driven by Westinghouse 25-hp., 440-v., 3-phase, 60-cycle, 1150-r.p.m. induction motors through Dayton Rubber Mfg. Co. Cog Belt drive. The third machine is driven by a 35-hp. Continental Motor Corp. gasoline engine through a Twin Disc Clutch Co. clutch.

3 Staynew Filter Corp., 250-c.f.m. Protectomotor filters on air compressors.

3 Manzel Bros. Co., Type XD force feed lubricators on air compressors.

4 S. F. Bowser & Co., Inc., Richardson-Phenix Type, ½-gal., 2-feed lubricators on ammonia compressors.

2 Westinghouse Electric & Mfg. Co., motor-generator sets for excitation current consisting of 9-hp., 440-v., 3-phase, 60-cycle, 1750-r.p.m. motors driving 5¾-kw., 125-v. direct-current generators.

2 Westinghouse Electric & Mfg. Co. motor generator for excitation current consisting of 16.5-hp., 1750-r.p.m., 440-v., 3-phase, 60-cycle motors driving 12.5-kw., 125-v. direct-current generators.

4 The Vilter Mfg. Co., 36-in. dia. by 18-ft. long horizontal multipass ammonia condensers with a surface of 1205 sq. ft. each.

1 The Vilter Mfg. Co., 35-t. brine cooler.

2 The Vilter Mfg. Co., super flooder boiler type 13,400-sq. ft. evaporating coils.

2 The Vilter Mfg. Co. ammonia accumulator.

1 The Vilter Mfg. Co., compressed air cooler with a surface of 155 sq. ft.

1 The Vilter Mfg. Co., dip water heater with a surface of 85 sq. ft.

1 The Vilter Mfg. Co., ammonia receiver.

1 Hill Mfg. Co., noncondensate gas separator.

1 The Vilter Mfg. Co., ammonia regeneration unit.

1 The Vilter Mfg. Co., oil and moisture separator in air line.

1 A. W. Cash Co., air pressure regulator valve.

1 The Vilter Mfg. Co. core water precooler with a cooling coil surface of 28 sq. ft.

2 The Vilter Mfg. Co., dehumidifiers in series with a brine coil surface of 53 sq. ft.

1 The Power Plant Specialty Co., cold process lime and alum water treater consisting of chemical treating tank and sand filters.

2 Dayton-Dowd Co., 65-ft. head, 1½-in. centrifugal brine pumps driven by Westinghouse 3-hp., 1750-r.p.m., 440-v. motors.

2 American Well Works, 40-ft. head, 40-g.p.m. centrifugal sweet water pumps driven by Westinghouse 1-hp., 440-v., 1750-r.p.m. motors.

1 Pomona Pump Co., 1350-g.p.m. deep-well centrifugal pump driven by a Westinghouse 60-hp., 440-v., 1750-r.p.m. motor.

2 Allis-Chalmers Mfg. Co., 250-g.p.m. centrifugal brine pumps driven by 10-hp., 440-v., 1750-r.p.m. motors.

5 Detroit Hoist & Mach. Co., 4-t. hoists, 4 monorail hoists over ice tanks and one transfer hoist.

8 The Vilter Mfg. Co., brine circulators driven by Westinghouse 5-hp., 440-v., 870-r.p.m. vertical motors.

1 Gifford Wood Co., ice dump conveyor driven by a 2-hp., General Electric 440-v., 870-r.p.m. induction motor through a W. A. Jones Fdry. & Mach. Co., 108 to 1 spur gear speed changer.

1 Viking Pump Co., Type ZK, 1½-in., core pump driven by a Westinghouse 1-hp., 440-v., 1750-r.p.m. motor.

1 The Vilter Mfg. Co., 11-can filler.

1 Klipfel Mfg. Co., 3-in. float valve in can filler.

1 Perfection Ice Scoring Machine Co. Clayton ice server.

1 Barrett Cravens Co. portable tierer.

Conveyors in ice storage, on loading dock and scoring machine and gig elevator.....Gifford Wood Co.

Switchboard .....Condit Elec. Mfg. Corp. .....Westinghouse Elec. & Mfg. Co.

Valves and piping.....Crane Co. .....The Vilter Mfg. Co.

Cork insulation.....United Cork Co.

Ice cans..Ohio Galvanizing & Mfg. Co.

Thermometers .....Consolidated Ashcroft Hancock Co.

Pressure gages... Bristol Co. / Federal Gauge Co. / Jas. P. Marsh & Co.

Meters Hersey Meter Co. / Pittsburgh Equiplite Meter Co.

Scales .....Fairbanks Co.

Lime.....Central Lime & Quarry Co.

Contractors.....Wm. Allen & Son Co.

emptied the pen makes a dip forming a permanent record.

Ice is harvested by 4-t. monorail hoists. Each tank is 22 cans (two 11-can racks) wide and each section has a 4-t. monorail hoist. In the rear of the tanks, immediately in front of the dump rack is a 4-t. transfer hoist which takes the hoist and can rack from any of the four-tank monorails to the monorail over the dump rack.

Arrangement of the dump rack is shown by the section Fig. 3. Water for the dip tank is warmed in a small multipass heater preceding the condenser in the hot gas line. After the cakes are loose in the cans, the rack is tipped as shown and the cakes slide by gravity onto the conveyor platform. The conveyor draws them forward and they slide one by one through a self-closing door through a pivoted circle run into the day storage. This circle run is reversible and delivers the cakes onto a reversible plate conveyor which takes them into either

FIG. 8. ICE FROM THE DUMP RACK COMES BY GRAVITY ONTO THE DAY STORAGE CONVEYOR

one of the two-day storages, or, if desired, to the gig elevator in the season storage.

Advantage has been taken of the natural slope of the ground to eliminate any elevating except that necessary for storing in the season storage. The reversible plate conveyor extends the length of the two-day storages as shown in the plan and discharges at one end to a feed conveyor for the Gifford Wood scoring machine, through which the cakes pass on the way to the loading platform. A double chain conveyor runs the full length of this platform to facilitate loading a number of trucks at once. The scoring machine is on one end of the platform and a dispatcher's office on the other end immediately over the cash-and-carry ice station. The dispatcher receives all orders and is in touch with the delivery trucks in all parts of the city through regular telephone calls. The delivery system of the three plants is coördinated and directed from this point.

By means of the double gig elevator, ice in the season storage can be stored 18 tiers high giving a storage capacity of about 1400 t. In the day storages, ice could be stored 12 tiers high by means of a portable conveyor, giving an additional capacity of 1600 t. if necessary and making a total storage of 3000 t. The storage is designed with unnecessarily high ceilings so that mezzanine floors can be added later to give additional day storage when the plant capacity is increased at a later date.

Storage rooms are insulated with sheet cork and equipped with buck stays and elevated slat floors to allow free circulation and protect the cork. Construction is shown by the photograph Fig. 8 and by the details Fig. 6. The floor is made of a 1⅝ by 10-in. plank subfloor laid on packed cinders. The floor also of 1⅝ by 10-in. planks is laid on 4 to 6-in. stringers placed directly on the subfloor. Inside walls are insulated by 4 in. of cork and outside walls by in. of cork, laid up in asphalt as shown in the drawing, and the roof by 6 in. of cork, asphalt, roofing and waterproof paper laid on 1⅝-in. sheathing supported on 4 by 6-in. joists.

Increase in Water-Power Development in 1930 Over a Million Horsepower

TOTAL CAPACITY of water wheels at water-power plants in the United States on January 1, 1931, according to the annual report just released by the Department of the Interior through the Geological Survey, was 14,884,667 hp., an increase of 1,076,889 hp., or 7.2 per cent, during 1930. This increase has been exceeded only in 1929 and 1926, when the increases were 1,276,000 and 1,138,000 hp., respectively. These figures indicate that the utilization of the country's water-power resources is proceeding at a fair rate, notwithstanding the continued improvement in the efficiency of steam plants. The States that show an increase of about 100,000 hp. each during the year are widely distributed—New Hampshire, New York, South Carolina, Tennessee, Alabama, and Washington.

The following table shows the total capacity of water wheels in different sections of the United States on January 1, 1930 and 1931, and the increase during 1930:

Capacity of water wheels, in horsepower

	January 1, 1930	January 1, 1931	Increase (per cent)
United States	13,807,778	14,884,667	7
New England	1,642,670	1,897,591	16
Middle Atlantic	2,113,313	2,211,663	5
East North Central.	1,075,434	1,092,414	2
West North Central.	551,102	566,766	3
South Atlantic	2,657,289	2,918,379	10
East South Central.	1,168,992	1,363,653	17
West South Central.	49,237	49,237	0
Mountain	1,184,528	1,217,388	8
Pacific	3,365,213	3,567,576	6

The complete report shows the total capacity of water wheels in plants of 100 hp. or more by States and main divisions of the United States, segregated between public-utility companies and manufacturing companies, the development in different sections of the country, and the rank of the ten leading States in developed water power from 1921 to 1931. Copies of the complete report may be obtained upon application to the United States Geological Survey, Washington, D. C.

Vertical Circulating Pumps Prove Popular

RECENT DEVELOPMENTS IN SCREW AND PROPELLER PUMP DESIGN OFFER ADVANTAGES WHICH HAVE BEEN UTILIZED IN NEW STATIONS

VERTICAL CENTRIFUGALS, screw propeller pumps of both the horizontal and vertical type are not new but until recently their use in the power plant field was negligible. Recent improvements in pump design and improvements in the conventional condenser circulating water arrangement, have changed conditions considerably, however, and there has been a decided increase in interest in equipment of this kind, especially in plants where the screen house is separate from the power house.

Considerable interest was created by the installation of Worthington verticals at Crawford Ave. station a few years ago. This was followed by the vertical Allis-Chalmers centrifugals at State Line and by the vertical Foster Wheeler centrifugals at Powerton. The State Line screen house arrangement is shown by the left-hand sketch in Fig. 1. The Powerton arrangement is somewhat similar and one of the 72-in. pumps, said to be the largest vertical centrifugal ever built for condenser work, is shown by Fig. 2. This pump has a rated capacity of 107,000 g.p.m. at 12.05 ft. total head. The combined capacity of two such pumps operating in parallel against a 19-ft. head is 160,000 g.p.m. At maximum load, the efficiency will be in excess of 87 per cent.

The James H. Reed station installation of vertical propeller pumps, shown in the center of Fig. 1, is a recent installation which has created a great deal of interest. The New Harding Street plant will also use vertical centrifugals in what is undoubtedly the most flexible and efficient installation ever built. The application of a horizontal Fairbanks-Morse screw pump is shown at the right of Fig. 1.

Application of the screw and propeller pumps with maximum efficiencies as high as 85 per cent is the latest development in the condenser field or for that matter in any field requiring the handling of large volumes at low heads. The Westinghouse company alone has installed or is now installing some 33 such units ranging from 10 to 72 in. in size, with capacities from 1850 to 157,750 g.p.m. for heads ranging from 12.5 to 24 ft. The propeller and guide vanes for one of the 72-in. units installed at the Ford* plant is shown by Fig. 3. The simplicity and compactness of this pump is shown by the sectional drawing at the left of Fig. 4.

FIG. 2. VERTICAL 72-IN. CENTRIFUGAL FOR POWERTON

Water is guided into the propeller P through the nozzle formed by the guide cone C and the bell shaped entrance to the pump. From the propeller, the water passes through guide vanes G to the body of the pump,

*See "Ford Completes Largest High Pressure Plant," p. 354, March 15, 1931.

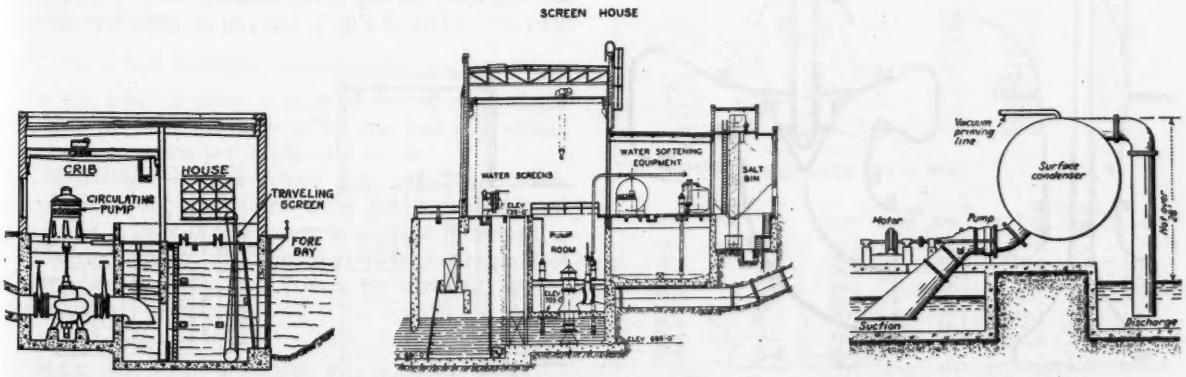


FIG. 1. VERTICAL CENTRIFUGALS AS USED AT STATE LINE (LEFT) VERTICAL PROPELLER PUMPS AT JAMES H. REED STATION (CENTER) AND SUGGESTED ARRANGEMENT OF HORIZONTAL SCREW PUMPS (RIGHT)

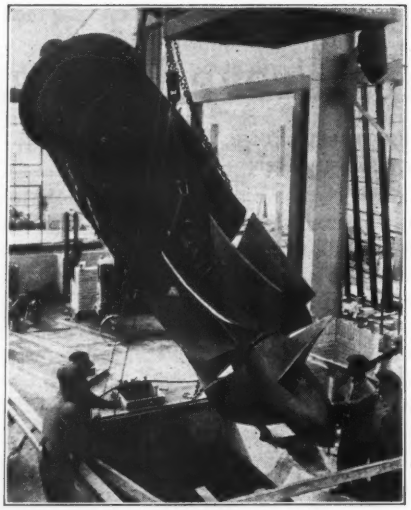


FIG. 3. PROPELLER PUMP, CAPACITY, 157,000-G.P.M., FOR THE FORD PLANT

built in the form of a diffuser with a splitter S installed at the discharge elbow to reduce losses at that point. A renewable liner, L, is fitted with liberal clearance since the efficiency of the pump is not affected appreciably by the amount of this clearance. A water lubricated rubber bearing B takes the radial load and the combined weight of pump and motor is carried by the feet, F. The one gland A is always under pressure.

Guide cone, C, is used only when the tunnel dimensions are limited. If the inlet tunnel is sufficiently large this cone is replaced by a bullet shaped nut on the end of the shaft. When desirable the pump may be installed either vertically or horizontally in the pipe line and a gate valve immediately adjacent to the impeller does not impair the efficiency.

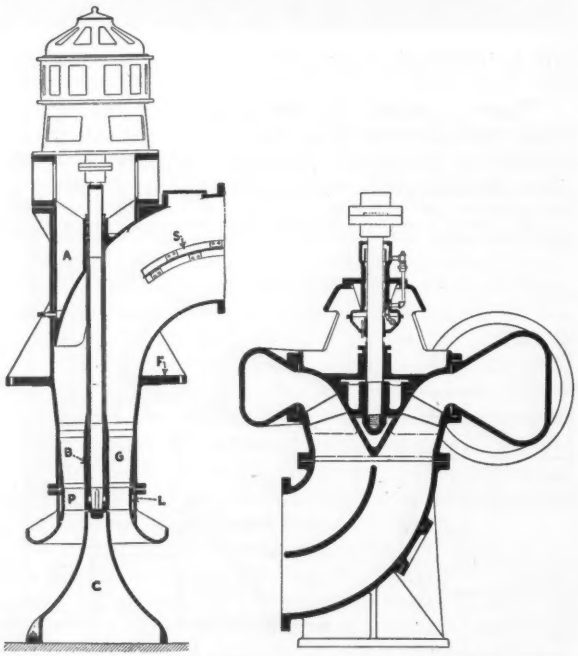


FIG. 4. (LEFT) CROSS SECTION OF A VERTICAL PROPELLER PUMP WITH GUIDE VANES. (RIGHT) SECTION OF A SCREW PUMP WITH A VOLUTE

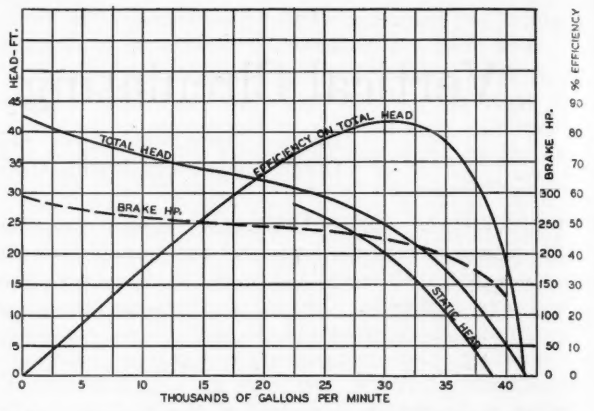


FIG. 5. PERFORMANCE OF A 36-IN. PUMP SHOWING THE TYPICAL SCREW PUMP HORSEPOWER CHARACTERISTIC, HIGHEST AT THE NO FLOW POINT

Small space and foundations required are a decided advantage. Operating speeds are high, ranging from 275 to 3000 r.p.m. and varying inversely with the size. They may be either motor or turbine driven and may be arranged to be reversible, to facilitate cleaning condensers. For marine condensers supplied with scoop injection at normal speed, the pump will idle in the stream with the steam off and arranged to start automatically or manually when the speed is reduced beyond a predetermined point.

There is said to be no minimum limit to the head for which it can be applied and produce maximum efficiency. The only factor that limits the maximum head at best efficiency is the velocity through the propeller. This velocity must be kept within the limit that can be obtained safely with the available absolute pressure at the propeller inlet and it is evident that if the pump can be submerged under a positive head of fluid a higher velocity through the propeller is possible and a correspondingly higher head can be obtained at the point of best efficiency. Numerous experiments have proved that the value of the maximum efficiency obtained is not affected by the head and capacity conditions for which the pump may be designed so long as the velocity through the propeller does not too closely approach the maximum velocity theoretically obtainable.

Another type of vertical screw pump is shown at the right of Fig. 4. This particular unit is a Morris 36-in. screw propeller pump built with a solid volute casing and was built for dry pit service similar to the arrangement at the left of Fig. 1, but can be built for wet well

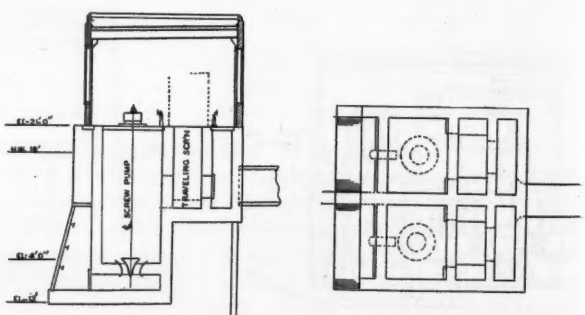


FIG. 6. SHOWING HOW THE VERTICAL PUMP CAN BE UTILIZED TO REDUCE SCREEN HOUSE COSTS

service where desirable. The characteristic curve of this pump at 450 r.p.m. is shown by Fig. 5. In many cases horizontal installation is desirable. The screw pump is readily adapted to installations of this kind as shown by the arrangement at the right of Fig. 1 suggested by Fairbanks-Morse.

In addition to the smaller space occupied by the propeller or screw pump, it may be operated at comparatively high speed, giving a considerably greater capacity and so reducing the size and weight per unit of capacity. For instance the 72-in. vertical centrifugal of Fig. 2 delivers 107,000 g.p.m. of water at a total head of 12.05 ft. when driven by a 500-hp., 205-r.p.m. motor. The 72-in. propeller shown in Fig. 3 delivers 157,750 g.p.m. against a 14.5-ft. head when driven at 275 r.p.m. by a 700-hp. motor.

One of the characteristic features of screw pumps is the shape of the horsepower characteristic which is highest at the shut-off head and drops (usually continuously) to free discharge as shown by Fig. 5. For this reason it is desirable to arrange these pumps so that they can be started up with the discharge line wide open. Otherwise the pump will require an excessive amount of power for starting and a considerably larger motor. This is in contrast to the usual centrifugal pump which shows a minimum power consumption at shut-off head and a peak somewhat beyond the maximum efficiency point.

Another important advantage of the vertical screw pump is in connection with screen house costs*, particularly where the fluctuation between high and low water level is considerable. Screw pumps installed as shown in Fig. 6 on the entrance side of the screen would make it possible to use comparatively short screens and save a great deal of expensive excavation. Even under conditions where the water level is comparatively constant, building costs can be reduced considerably. A comparison of various layouts will show how a vertical pump in some cases would have reduced the building from 25 to 30 per cent in size.

*See "Screen House Costs Must Be Lowered," by A. Streiff, p. 862, August 1, 1930.

Comparison of Natural Gas Fuels

PART II. SIGNIFICANCE OF HIGH AND LOW HEATING VALUES; DETERMINATION OF HEATING VALUE BY MEANS OF CHART. BY PALMER B. PLACE

HEATING VALUES of a gas may be given in terms of B.t.u. per cu. ft. at some temperature and pressure or in terms of B.t.u. per lb. and in both cases the value may be a "high" or "low" one. It is necessary, therefore, when comparing several gases, that the heating value of each be on the same basis or conclusions drawn may be misleading.

Usually, the "high" heating value in terms of B.t.u. per cu. ft. at 60 deg. F. is given. A better basis for comparison of the heating values of manufactured or natural gas fuels, is the B.t.u. per pound for the following reasons:

1. The pound requires no temperature or pressure qualifications.

2. The pound is the common basis for solid and liquid fuels and for combustion and heat balance calculations.

3. The heating value of a natural gas is proportional to the amount of carbon and hydrogen that it contains when these elements are expressed gravimetrically in an ultimate analysis.

NATURAL GAS SAMPLES SELECTED FOR COMPARISON

In the table is given a selected list of natural gas samples with their analyses by volume and weight and their heating values per cu. ft. and per lb.

The method of converting the usual volumetric analysis into the gravimetric form has been developed in the first article of this series, which was published in the March 15 issue. The heating value per cubic foot is converted to B.t.u. per pound by dividing by the proper density as follows:

Sample No. 1.
B.t.u. per cu. ft. at 60 deg. F..... 1002
Gas density lb. per cu. ft. at 60 deg. F...0.0427
B.t.u. per lb. 1002/0.0427 = 23466

Water vapor is the product of combustion of hydrogen, either in the free or combined state. When products of combustion, containing water vapor are cooled sufficiently, the vapor condenses and gives up its latent heat of condensation. The heating value of fuels as determined in a calorimeter, includes this latent heat

ANALYSIS OF TYPICAL NATURAL GAS SAMPLES

1. Volumetric Analysis - Basis, cu.ft. at 60 deg. F.

Sample	Methane	Ethane	Propane	Carbon dioxide	Nitrogen	Heat value B.t.u.	Density lb. / cu.ft.
1.	98.5	-	-	-	1.5	1002	0.0427
2.	91.3	4.5	-	0.8	3.4	999	0.0455
3.	84.7	9.4	4.3	-	1.6	1126	0.0494
4.	80.5	18.5	-	-	1.0	1140	0.0494
5.	73.2	25.6	-	-	1.2	1188	0.0521
6.	77.5	16.0	-	6.5	-	1061	0.0529
7.	50.6	10.9	-	0.1	38.4	702	0.0585
8.	59.1	14.5	-	25.1	1.3	849	0.0665
9.	32.2	67.0	-	-	0.7	1482	0.0672
10.	-	31.8	67.7	-	0.5	2269	0.1038

2. Gravimetric Analysis - Basis, 1 lb.

							Molecular weight
1.	97.4	-	-	-	2.6	23466	16.18
2.	84.7	7.8	-	2.0	5.5	21956	17.26
3.	72.4	15.1	10.1	-	2.4	22793	18.71
4.	68.8	29.7	-	-	1.5	25077	18.71
5.	59.4	38.9	-	-	1.7	22802	19.73
6.	61.8	23.9	-	14.3	-	20057	20.06
7.	36.5	14.8	-	0.2	48.5	13000	22.16
8.	37.5	17.3	-	43.8	1.4	12767	25.21
9.	20.3	78.9	-	-	0.8	23053	25.47
10.	-	24.1	75.5	-	0.4	21860	39.47

3. Ultimate Analysis - Per cent by weight

	Carbon			Hydrogen					Inerts	
	Total	Inert	Comb	Total	Inert	Comb	C	O_2	N_2	Total*
1.	73.0	-	73.0	24.4	-	24.4	-	-	2.6	2.6
2.	70.3	0.5	69.8	22.7	-	22.7	0.5	1.5	5.5	7.5
3.	74.6	-	74.6	23.0	-	23.0	-	-	2.4	2.4
4.	75.4	-	75.4	23.1	-	23.1	-	-	1.5	1.5
5.	75.7	-	75.7	22.6	-	22.6	-	-	1.7	1.7
6.	69.4	3.9	65.5	20.2	-	20.2	3.9	10.4	-	14.3
7.	39.5	0.1	39.2	12.1	-	12.1	0.1	0.1	48.5	48.7
8.	55.9	11.9	43.0	12.8	-	12.8	11.9	31.9	1.4	45.2
9.	78.5	-	78.5	20.9	-	20.9	-	-	0.6	0.6
10.	81.1	-	81.1	18.5	-	18.5	-	-	0.4	0.4

* These values for use in Figure 2.

and is termed the high, or gross heating value of the fuel.

In the commercial generation of steam, however, the exit gases from the boiler are never allowed to cool to the point of condensation and so the heat of condensation of the moisture formed by the combustion of the hydrogen in the fuel is never available as useful energy. For this reason the latent heat is sometimes deducted from the high heat value and the lower value is termed the low, net or available heat value of the fuel.

Latent heat of condensation varies with the temperature at which condensation occurs and with the partial pressure of the water vapor and so arbitrary values have to be assumed in calculating this low heat value. Latent heat values of 1040, 1050, 1055 and 1080 B.t.u.

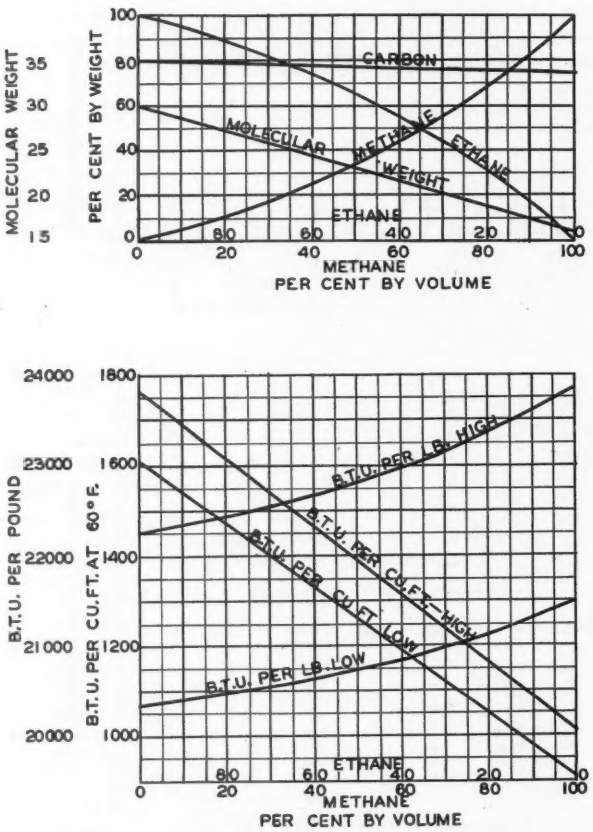


FIG. 1. ANALYSIS AND HEATING VALUE OF METHANE-ETHANE MIXTURES

per lb. are commonly used. In the present discussion, the value 1050 B.t.u. per lb. has been used in calculating the net heating value of the gases listed and the method is as follows:

Sample No. 1.

High heat value, B.t.u. per lb.....23,466
Per cent hydrogen by weight.....97.4 × 0.25 = 24.35
Water formed, lb. per lb. fuel.....0.2435 × 9 = 2.19
Latent heat loss, B.t.u. per lb.....2.19 × 1050 = 2300
Net heating value, B.t.u. per lb.23,466 — 2300 = 21,166

Though valuable in comparing the economic value of gas fuels having a high percentage of hydrogen, and in estimating the efficiency with which they may be burned, net heat values should be used carefully when the method of calculation is not definitely known.

Heating Value and the Ultimate Analysis by Weight

In calculating the ultimate analysis, the method of which has been described in another article, the difference between combustible and non-combustible carbon and hydrogen should be understood. The combustible elements of natural gas fuels are carbon and hydrogen of the hydrocarbons in the gas and the non-combustible elements or inerts may be nitrogen, oxygen from carbon dioxide and water vapor, carbon from carbon dioxide, and hydrogen from water vapor. (Note: Some natural gases contain other combustible and non-combustible gases, such as hydrogen sulphide and helium, etc., but these are not common and they have been ignored as their consideration would unnecessarily complicate the development of the methods of comparison.)

Figure 1 shows the relation between the high and low heating values and the analysis of mixtures of methane and ethane. Most natural gases consist of these two gases diluted with a small amount of inerts. Note the small variation in the ultimate carbon content by weight for large variations in the molecular weight (density) and the resulting small variations in the heat value per pound as compared with the heat value per cubic foot.

Figure 2 shows the heating value for any natural gas fuel in terms of an ultimate analysis by weight of combustible carbon, combustible hydrogen and non-combustible inerts. Thus, a natural gas containing 75 per cent carbon, 20 per cent hydrogen and 5 per cent carbon dioxide, nitrogen or other inerts, has a heating value of 21,500 B.t.u. per lb. (Note: This chart is not applicable to natural gases containing hydrogen sulphide, free hydrogen or other combustible gases other than hydrocarbons.)

The shaded area in Fig. 2 represents various mixtures of methane, ethane and inert diluents.

Of two gases having the same gross heating value in B.t.u. per pound, the one having the greater carbon content will have a lower latent heat loss due to the combustion of the hydrogen in the fuel. For example, selecting two samples from Fig. 2:

	No. 1	No. 2
Heating value, B.t.u. per lb	22,000	22,000
Per cent carbon by weight	69.5	78.5
Per cent hydrogen by weight	23.0	20.0
Per cent inerts by weight	7.5	1.5
Moisture formed, lb. per lb. fuel	2.07	1.80
Latent heat loss, B.t.u. per lb. fuel	2184	1890
Net heat value of fuel, B.t.u. per lb	19,816	20,110

Comparison of the heat values of the ten selected samples as determined from Fig. 2 and the ultimate analysis, with the measured heat values given in the table reveals that the average deviation is less than the accuracy with which a curve may be read.

Other Factors Affecting Heat Values

There are other factors which should be considered when comparing the relative value of two or more natural gas fuels.

Inerts in fuel gases have somewhat the same effect

as ash in solid fuels. Gases having a high percentage of non-combustible material require extra handling of the raw gas, yield a somewhat lower temperature when burned, produce a slightly larger quantity of waste gases per B.t.u. and require a longer time to complete combustion; hence they require a larger furnace. Otherwise stated, the heat liberation per cubic foot of combustion space will be less for diluted gases than for rich gases. In this respect the effect of inerts in gas fuels is more noticeable than the effect of ash in solid fuels. The reason for this is that gaseous fuels have to depend chiefly on diffusion to bring the molecules of oxygen into contact with the combustible portion of the fuel,

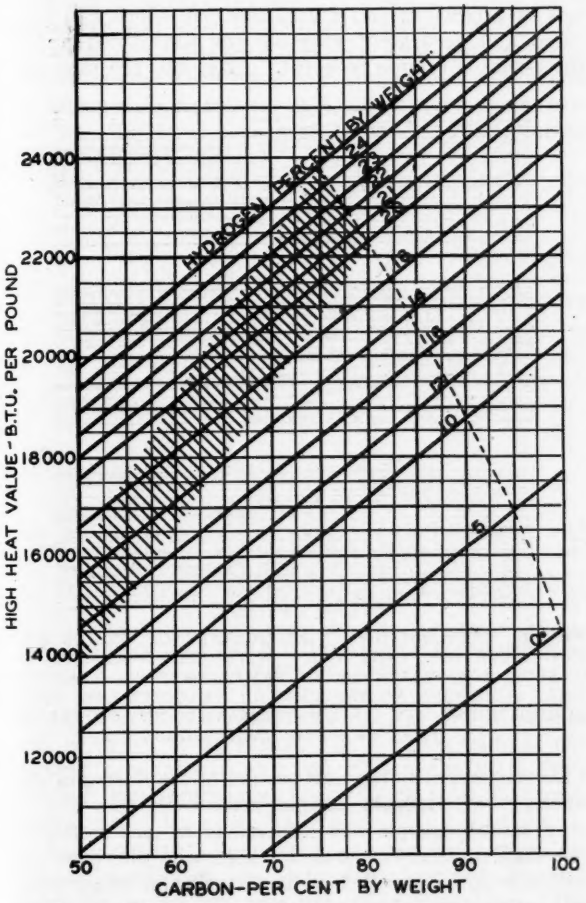


FIG. 2. HEAT VALUE OF NATURAL GAS FUELS FROM ULTIMATE ANALYSIS (AS FIRED)

and the inert gases present tend to blanket the fuel and reduce the velocity of this contact. With solid fuels, however, a difference in velocity of fuel and air supply may be maintained, because of the relative densities of solid and gas, and thereby the air may be brought into contact with the fuel more quickly than by diffusion alone. Also with solid fuels, as fast as ash is formed by combustion, it tends to fall away and expose fresh fuel surfaces. This does not mean that gases will burn less rapidly or less completely than solid fuels but only that the reduction in the rate of combustion will be more affected by the presence of inert diluents than will the combustion of solid fuels by the presence of ash forming material.

Amount of air required for combustion, quantity of waste gases produced, relative flame temperatures and probable heat balances and efficiencies of various natural gas fuels, will be considered in subsequent articles.

A. S. T. M. to Try New Plan of Presenting Papers at June 23 Meeting

ATTEMPT TO SOLVE the problem of stimulating discussions of a program of engineering papers will be made at the June meeting of the American Society for Testing Materials to be held June 23, Hotel Stevens, Chicago, Ill., it is announced. At this meeting two sessions will be devoted to a joint symposium of the A.S.T.M. and the A.S.M.E. on the engineering problems involved in the use of metals at high temperature. The symposium will deal with the engineering trend in the needs of the power plant, oils, chemicals, metals, automotive and ceramic industries for metals for high temperature service and with the properties of available materials for such service.

There will be about thirty papers, the authors of which have written them with the express understanding that no author is to present, nor even to summarize, his own paper according to H. W. Gillett, of Battelle Memorial Institute, Columbus, Ohio, chairman of the Symposium Program Committee. The high spots of all the papers on this general subject, The Engineering Needs of the Industries, will be summarized at the first session by a representative of the joint committee of the A.S.T.M. and A.S.M.E. on the effects of temperature on the properties of metal, which committee is sponsoring the symposium. Another representative of the committee will summarize the papers on the properties of the various alloys for the second session. Neither representative has written any of the papers and his part is to set forth a general picture of the situation as it is brought out in the individual detailed papers. The subject will then be thrown open to discussion with the authors ready to answer questions that will be asked them; otherwise, the authors will be seen but not heard.

By this arrangement, it is hoped to combine advantages of giving for reference a complete picture of the engineering situation in the printed transactions with active and interesting discussions at the meeting itself.

Of course the papers must be pre-printed and in the hands of the society members and guests who will wish to discuss them well in advance of the meeting. This is being arranged for at present, according to the committee and those who are interested in discussing high and low temperature needs and properties of metals may secure copies the pre-prints from C. L. Wallace, Secretary, American Society for Testing Materials, 1315 Spruce St., Philadelphia, Pa., about May 10.

DO NOT ATTEMPT arc welding or permit other open flames where gasoline or other inflammable fumes may be present. Ventilate rooms where such work is performed and, before undertaking to weld or cut containers that have held inflammable liquids or gases give them a thorough purging. When working on batteries, open flames should be avoided. Use electric soldering irons where practicable.

Measuring Ash Content of Flue Gases

Details of Equipment and Methods for Sampling and Obtaining Data

GROWING IMPORTANCE of the fly ash problem with the increased utilization of pulverized coal makes it necessary for the engineer to have some method of determining the amount of solids being carried by the flue gas or for sampling pulverized coal lines to the burner as the case may be.

Details for making these tests, with particular reference to flue gas testing where the breeching is under a slight draft and the sample must be drawn out by means of an aspirator, were described by J. W. Mackenzie before the A.S.M.E. In this case a section of breeching was divided into 12 equal parts and a sample of gas with its entrained solids taken from the center of each section.

Apparatus used for the collecting of the samples is shown in Fig. 1, and consists of a thin-walled sampling pipe (a) connected to a vacuum bag (b) through an air-operated ejector (c) with a valve (d) for controlling the flow in the sampling pipe. The sensitive inclined

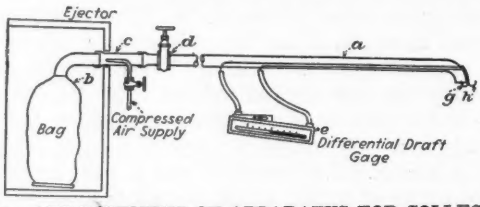


FIG. 1. ARRANGEMENT OF APPARATUS FOR COLLECTING SAMPLES

draft gage (e) is connected to indicate the differential pressure between the pitot tube (g) with its open end in the entrance of the sampling pipe and the pitot tube (h) with its open end outside the sampling pipe. It will be noted that the pitot tubes are turned with the flow of the gases which would theoretically show the static head minus the velocity head. This arrangement was adopted due to the fact that if the pitot tubes are turned against the flow of the gases they become clogged with fly ash. While this arrangement is not accurate for actually measuring velocity, tests made with a sampling tube equipped with both types of pitot tubes showed that the arrangement adopted was satisfactory for establishing the same velocity into the tube as existed in the surrounding area.

It is important in obtaining samples of this kind that the rate of flow into the entrance of the sampling tube be the same as the velocity of the gases past the tube. Not only will the total quantity of solids vary with the velocity of the gases entering the tube but the percentage of fines will also be affected. This is more readily understood by referring to Fig. 2. If the velocity into the sampling tube exceeds the velocity of the surrounding gases, some of the superfine materials which would otherwise pass the sampling pipe are diverted from their normal path and carried into the tube. Since the finer particles are more easily deflected, the percentage of fines in this sample will show too large.

If, on the other hand, the velocity into the sampling tube is lower than that of the surrounding gases, some of the gases are forced outside the area of the sampling pipe entrance, resulting in less total solids in the sample and too low a percentage of fines. By maintaining the same velocity within as without the sampling pipe, the least possible disturbance to the gase stream is obtained with a quantity and quality of sample which is characteristic of the total material in the gases. To insure this minimum disturbance at the entrance of the sample pipe, it is desirable to use a thin straight-walled tube, with the entrance edges sharpened, for this purpose.

Procedure for collecting the samples was to set the sample tube to draw from the center of one section of the duct area, and, with a vacuum-cleaner bag in place, the ejector was started and the flow in the sample tube adjusted by means of the valve (d). The vacuum bag was then removed and a duplicate bag which had been dried and accurately weighed was substituted and a three-minute sample collected. After this the sampling

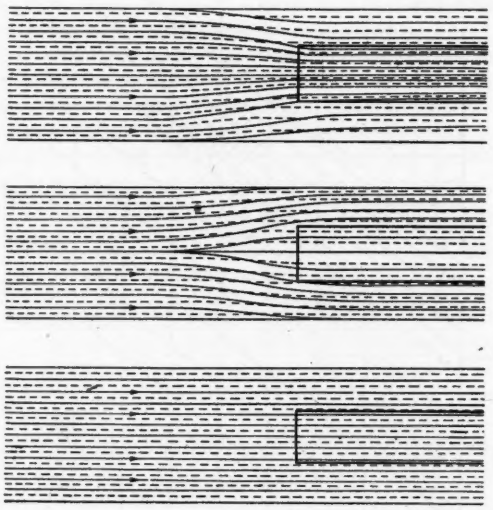


FIG. 2. SHOWING HOW THE QUALITY OF SOLIDS AND PER CENT OF FINES VARY WITH THE VELOCITY OF GASES. TOP, VELOCITY IN SAMPLING PIPE GREATER THAN SURROUNDING GAS; CENTER, VELOCITY LESS THAN SURROUNDING GAS, AND BOTTOM, VELOCITY EQUAL TO THAT OF SURROUNDING GAS

tube was moved to the next section of the duct area and another three-minute sample taken. In this way, a three-minute sample was gathered from each section of the duct, careful watch being kept with the gage (e) and the flow controlled so as to maintain equal velocities of the sampling end of the tube. The vacuum-cleaner bag was then dried and re-weighed. The increase in weight times the ratio of the area of one section of the duct to the area of the entrance of the sample tube is equal to the total solids passing through the duct in a three-minute period.

When obtaining pulverized coal samples the duct is usually under a slight pressure and the compressed air supply, or aspirator is not required as the pressure in the duct is sufficient to give a flow out of the sampling tube to the filter bag. Considerable discussion regarding the accuracy of this method of testing has taken place and it is probable that the velocity through the sampling tube is greater than the velocity in the duct itself, resulting in a condition similar to the top of Fig. 2 and showing somewhat too large a percentage of fines in the sample.

Welded Steel Pipe in Turbine Construction

DETAILS OF 82-IN. STEEL PIPE CONNECTING ELEMENTS OF CROSS-COMPOUND TURBINE. BY HAROLD L. ALT

THIS UNUSUAL piece of pipe work was recently completed for a public service company. The pipe is practically 7 ft. in diameter, the exact inside dimension being 82 in. with the shell and reinforcing rings coming outside of this. It was built for the purpose of carrying steam from the high-pressure unit to the low-pressure unit of a Westinghouse cross-compound steam turbine and it is expected to carry about 1,600,000 lb. of steam per hour at 40 lb. absolute pressure. When starting or stopping the units, however, conditions involving a vacuum may be set up so that the pipe not only had to be designed to withstand 40 lb. absolute inner pressure but was also strengthened so as not to collapse under 29½ in. of vacuum.

From center to center of the turbine connections, the

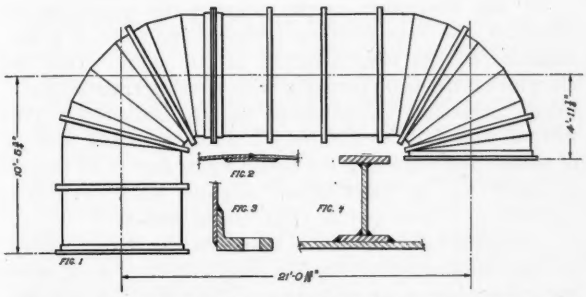


FIG. 1. COMPLETE CROSS CONNECTION BETWEEN THE HIGH-PRESSURE AND LOW-PRESSURE SIDES OF A CROSS-COMPOUND STEAM TURBINE
FIG. 2. DETAIL OF METHOD USED IN FORMING LONGITUDINAL JOINTS
FIG. 3. METHOD EMPLOYED IN FORMING UP FLANGES
FIG. 4. BUILT-UP I BEAM USED AS REINFORCEMENT TO PREVENT COLLAPSE

pipe is a trifle over 21 ft. long and has elbows on each end, as shown in the sketch, Fig. 1. It consists of two straight sections and the two elbows, the plate from which it was constructed being ⅜ in. thick and reinforced with I beams and angles.

In constructing the elbows, the templates were laid out and marked on the plate; the plate was then cut according to the template and rolled into shape. The longitudinal joints were temporarily bolted together at each end and then welded the entire length. A butt strap was then placed over the joint and welded in position so that there would be no temperature stresses on the joint. A detail of the longitudinal joints is shown in Fig. 2.

Practically all the welding done on this pipe was arc welding and no holes were drilled until after the rolling and welding were completed.

Flanges were constructed from angle iron lap welded in place, as shown in detail in Fig. 3; this method of treatment helps to distribute stresses caused by temperature changes.

Owing to the fact that the steam pressure is likely to drop from its highest point down to an almost perfect vacuum (29½ in.) it was necessary to stiffen up the pipe so as to prevent its being crushed in by atmospheric pressure when the high vacuums occur. The scheme first contemplated was to use an I-beam with the flange welded to the pipe plate. Various manufacturing difficulties were encountered in trying to bend the web of a stock structural beam to a radius parallel with the web.

It was then decided to retain the I-beam form but to build it up from three pieces of steel, the part forming the web being cut in circular form from a flat plate and to suit the radius required. Thus the web of the built-up section did not require bending. The top and bottom flanges were then bent to conform to the proper radius and were welded to the circular web. This is illustrated in Fig. 4. The web was made in six segments and from ¼-in. plate, and the flanges were made from ⅜-in. plate.

On completion the pipe was subjected to a hydrostatic pressure of 80 lb. per square inch, under which

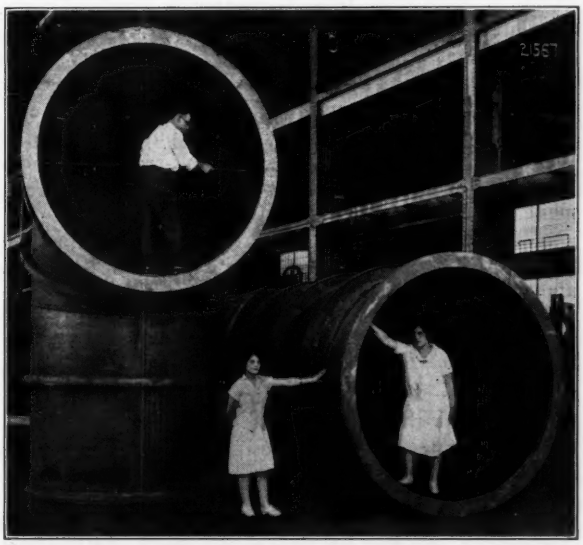


FIG. 5. WELDED STEEL PIPE BUILT FOR VACUUM AND PRESSURE SERVICE

pressure it stood for several hours with no leaks developing.

Some idea of the enormous size of this pipe may be gained by viewing the photograph accompanying this article which shows the pipe compared in size with a person of average height. It is said that this is the world's largest steam pipe and, whether this claim is justified or not, the work forms an outstanding example of pipe fabrication.

IN A CENTRIFUGAL pump, the head to be developed determines the peripheral speed of the impeller. This peripheral velocity and the speed of the prime mover determine the diameter of the impeller. The capacity to be delivered determines the eye or inlet size and the width of the impeller. In order to have the highest efficiency, there must be certain ratios maintained between these various factors, so that it may not be practical to let the prime mover determine the speed in all cases. In order to get the best pump, it may be advisable to let the pump determine the speed of the prime mover.

Concentration Control of Boiler Water

Tests to Determine Amount and Character of Impurities; Removal of Suspended Matter; Reduction of Concentration. By Herbert S. Whiton[1]

CONCENTRATION control is a mechanical problem plus a chemical problem, since the modern steam boiler is in effect a huge laboratory retort into which water is introduced ranging from nearly pure to a relatively concentrated solution of salts. Complex reactions take place within this retort due to the effect of heat and pressure on the dissolved salts and on other chemicals which may be introduced to alter the composition of the water for elimination of scale and reduction of corrosion.

Obviously, if boiler water were free from dissolved salts and suspended matter or other impurities, no concentration could be built up by evaporation. Unfortunately, chemically pure feedwater is practically unknown to the art. Hence, all boilers are subjected to concentration of the salts they contain since the steam carries out little or no impurities if it is reasonably dry steam. Of course, a priming boiler purges itself of considerable dirt along with the steam, but priming and foaming cannot be allowed in a well-regulated boiler plant. They can be avoided by proper feedwater treatment and control of concentration in the boiler.

Many boilers do not prime but furnish steam just wet enough to carry away minute quantities of salts and solids continuously. These materials often cause clogging of turbine blading and nozzles which reduces the load capacity of the unit and sets up undue thrust. Very careful concentration control is often needed in such cases, as a small increase in concentration may materially affect the carryover at some point in the concentration range, whereas at lower concentration a large difference in density may make no appreciable difference in carryover.

Methods of treating feedwater and of checking boiler water concentration vary widely in different plants, depending in part upon the nature of the water in use, the use to which the steam is put, the size, loading and design of the boilers, and the capacity and studiousness of the man responsible for water conditioning in the boiler plant.

Several methods of checking boiler water concentration are in successful use in various plants but vary widely in speed and accuracy.

Non-Chemical Test with Baume Hydrometer

Samples of water are withdrawn from the boiler through suitable cooling coils to prevent loss by flashing and to cool the sample to the temperature at which the hydrometer was calibrated, then the density is measured by floating the hydrometer in the sample. This reading indicates approximately the concentration of salts in the water but gives no indication of suspended matter. The permissible concentration, of course, varies with different waters. At a certain plant using filtered and zeolite softened water which contains about 600 parts per million of salts, considerable carryover and clogging of turbine blades was experienced before concentration of boiler water was measured and controlled. About 18 months ago, the hydrometer method was introduced and efforts made to hold boiler water concentration down to give a hydrometer reading below 0.4 at 60 deg. F. This has been done without difficulty and without excessive blowdown and has reduced carryover to an extent which avoids deposits on turbine blades.

Similar experience has been had at another plant using lime and soda softened water with continuous blowdown. Use of the hydrometer has enabled the operators to avoid excessive carryover and excessive blowndown.

Titration Test May Be Required

If the feedwater carries appreciable quantities of chlorides, the concentration of these chlorides is a fair measure of the concentration of all salts. Test for chlorides consists of titrating with silver nitrate solution, using potassium dichromate as an indicator. This method also fails to give any indication of the amount of suspended matter in the boiler water and is, of course, of little use in most inland regions since but little chloride will be found in most inland waters.

A comparable method is based on the determination of total alkalinity by titration with sulphuric acid, using methyl orange as an indicator. The ratio of total alkalinity in the boiler to that in the feedwater is a fairly close measure of the concentration of soluble salts in the boiler water.

These simple tests are valuable in any plant, but as the feedwater treating problem becomes complex they must be augmented by other tests if satisfactory results are to be obtained.

Test procedure may well be set up in such cases to determine the following:

1. Concentration of total salts.
2. Carbonate and hydroxide ions.
3. Chloride ions.
4. Phosphate ions.
5. Sulphate ions.
6. pH values.
7. Oxygen content.
8. CO_2 content.

Data from these tests enable the chemist to alter the chemical treatment of the feedwater and intelligently to regulate the concentration conditions within the boiler.

Concentration of total salts can be measured:

(a) By a hydrometer previously calibrated in terms of dissolved salts. Speed is the advantage of this method.

(b) By chemical determination of the carbonate, bicarbonate, hydroxide, sulphate, chloride and phosphate ions which are calculated to their respective sodium salts by the use of conversion factors. The sum of these salts approximates the total dissolved salt content of the water. Also the data resulting from these tests are all

[1]Assistant Mechanical Engineer, Byllesby Engineering Management Corp. Paper read at the Midwest Power Engineering Conference.

useful in controlling boiler water conditioning. This method is more accurate than the use of a hydrometer, but is slow.

(c) By suitable electrical apparatus for measuring the specific conductance of the sample, in which the scale of the instrument may be calibrated in terms of dissolved salts by checking against a series of complete chemical analyses of the water, covering the necessary range. This method is both rapid and accurate.

All the above tests may be made by the plant personnel after suitable instruction by a competent chemist.

Sulphate determination is most readily made by the turbidimetric method.

Phosphate, if used in the reconditioning process, may be determined either by the volumetric procedure or by any standard gravimetric procedure.

The pH value[2] of the water is readily determined by the plant operator, using either a series of calibrated color cells or permanent glass color standards. More accurate results can be obtained by use of the electrical method.

Suspended Matter in Boiler Water

None of the above tests include determination of suspended matters, colloidal matter, oil or organic matter which may be in the water. These items may be investigated advantageously by a competent chemist at suitable intervals, but need not be made part of the daily routine.

The relation of and the amount of carbonate, hydroxide and sulphate ions and of phosphate, if used in the treatment, indicate whether proper treatment is being carried out and whether the boiler water is becoming too concentrated.

Local water supply, the amount of make-up, and local plant operating conditions govern the range in concentration of these ions. For example, in boilers supplied with pure feedwater in which there is introduced a small amount of condenser leakage, it may be desirable to permit in the concentrated boiler water a phosphate concentration between 25 and 100 p.p.m. In another plant because of the varying amount of and suddenness of condenser leakage, the contamination introduced into the feedwater, it may be desirable to hold the concentration of phosphate between 100 and 300 p.p.m. In both of these plants, alkaline ions, hydroxide and carbonate, introduced by virtue of reactions between the trisodium phosphate and the substances in the water, produce a hydroxide concentration not in excess of 30 p.p.m. and carbonate concentration of 100 p.p.m.

In boilers using a mixture of 70 per cent zeolite treated water and 30 per cent condensate returns, the hydroxide concentration has been limited to approximately 80 p.p.m. Particular emphasis is given to the hydroxide concentration because of the fact that this ion is considered by investigators in embrittlement as the primary chemical factor contributing to embrittlement. Again it must be observed that local plant conditions must be studied in order to determine the practical limit for the concentration of hydroxide and means to maintain this concentration within the desired limits. There are two other factors which must be considered in connection with the interpretation of the data, namely, the maintenance of the suggested embrittlement ratio and the pH value of the water.

In such boiler plants where the suggested ratio of sodium sulphate to sodium carbonate alkalinity is maintained, the control of treatment both external and internal to the boiler requires regulation so that the necessary relations may be obtained. This may imply acid treatment of the feedwater, addition of the sulphate salt to the feedwater, or a change in the treatment of the feedwater in order to limit the hydroxide concentration in the resulting boiler water. The control of boiler water by the pH value of the water may be considered to be a desirable means of establishing the noncorrosiveness of the boiler water. In other words, if a pH value ranging from 10.6 to approximately 11.2 can be maintained in the boiler water, there is predicated an arrest of corrosion due to the inherent corrosiveness of the water; particularly distilled water carrying but traces of oxygen, and there is further predicated the completeness of reactions which imply that the calcium and magnesium ions have been eliminated as sludge in the boiler water.

While materials containing hydroxide are requisite, or essential in the external treatment of feedwater, the presence of excess hydroxide within the boiler water may be considered burdening the boiler water with excessive material which has no softening value whatsoever.

It will be observed from the above that each local plant requires a study of its own for the establishment of the limits which will procure proper boiler metal conditions and suitable steam quality. As respects the concentration of the total solids within the boiler, such concentrations must be valued first from the standpoint of steam quality. In other words, after the boiler plant operator has secured a minimum of carryover in the steam, the conditions of concentrations of the boiler water within the boiler must be observed and these values maintained. As examples, in boilers evaporating a feedwater made up of 10 per cent lime and soda-ash treated Ohio River water, and 90 per cent condensate returns, a concentration of dissolved salts of 4250 p.p.m. is maintained in the drums of Stirling boilers without contaminating the steam. The blowdown requirements on these boilers average about 0.1 per cent of the water fed. In cross-drum boilers supplied with 100 per cent pure water and a limited amount of phosphate treatment, it has been observed that the input of dissolved salts into the boiler equals the carryover of salts by way of the steam generated in the boiler and with concentration of 800 p.p.m. within the boiler drum, it has been found possible to evaporate some 700,000,000 lb. of water without the necessity of blowing down or of removing the water from the boiler. In the multi-drum vertical type boiler using zeolite water, it has been found that concentrations below 2500 p.p.m. must be maintained in order to produce reasonably clean steam.

Methods of Reducing Concentration

Regardless of test methods used or water treatment selected, it may be necessary to remove considerable quantities of concentrated boiler water from any or all boilers in the plant and replace with less concentrated water in order to avoid excessive concentration in the

[2] pH is the symbol for the logarithm of the reciprocal of the hydrogen ion concentration.

boilers. Numerous methods are available for this purpose.

The simplest is the intermittent use of a hand-operated blowoff valve. This can be made effective if carefully checked, but is difficult of control when really bad waters are encountered which require blowing down large quantities of water.

In such cases, some system of continuous blowdown with heater exchangers is usually well worth while. In simplest form, such apparatus includes a regulating valve in a small line attached to the boiler below the water line. Adjustment of this valve regulates the rate at which concentrated water is withdrawn from the boiler. This water contains considerable heat per pound because it is at the temperature corresponding to the pressure in the boiler. This heat is wasted usually in blowing down intermittently, but in the continuous blowdown system much of it can be saved by the use of heat exchangers. The concentrated boiler water is passed through one side of the heat exchanger and the feedwater is passed through the other side on its way from the feed pump to the boiler. Thus much of the heat in the blowdown is returned to the boiler via the feedwater. The blowdown water can thus often be cooled to within about 10 deg. F. of the feedwater temperature. If an appropriate quantity of lower temperature water is needed about the plant, further savings can be made by use of another heat exchanger, using the cooled blowdown as heating medium. Whether this is an economic addition can be determined only by study of each case.

With a system such as described above, the regulating valve must be adjusted frequently as may be indicated by frequent tests of the boiler water, since the blowndown is not automatically varied with the load on the boiler or plant. At least one manufacturer of such equipment provides a thermostat to operate the regulating valve. This thermostat, immersed in the blowdown stream, increases the blowdown rate as the feedwater quantity increases, thus reducing the temperature of the blowdown water leaving the heat exchanger. The relation between blowdown and feed can be altered by regulation of the thermostat.

Location of Blowdown Connection

With either system, satisfactory results can be obtained if the apparatus is operated intelligently. An important point is the choice of the location for the continuous blowdown connection to the boiler, as less blowdown will be needed if this line removes the most concentrated water available than if it removes a less concentrated water.

There is but one sure way to determine the proper location for this connection because water in different boilers circulates differently and the application of water-cooled furnace walls may change the circulation.

Sampling pipes may be inserted at various points in the boiler, and at intervals samples withdrawn from all and tested by any of the above-mentioned methods. If the samples from any one connection show consistently higher concentration than the others, that location may be chosen for the continuous blowdown connection, provided the amount blown down may safely be taken there without upsetting the circulation at some "touchy" point of the boiler. Naturally, a small percentage blowdown is not likely to cause an upset in circulation no matter where the connection is made, but a high percentage blowdown may adversely affect circulation if taken from an improper location.

Regulation of Blowdown

Whether each individual boiler should have its own regulating valve and heat exchanger can be decided only after study of the conditions encountered in each case. It seems obvious, however, that in plants containing several boilers each should be equipped individually unless the load is divided proportionately between the boilers at practically all times. This applies particularly to the regulating valves. Various heat exchanger schemes can be worked out to suit conditions. One plant may be satisfactorily served by a single heat exchanger with multiple paths for the blowdown and a single path for the boiler feed. Another may require individual heat exchangers for best results and others may be best served by a combination of these schemes.

If thermostatic valve control is used to proportion blowdown to feed, individual heat exchangers are indicated, each boiler being equipped with a heat exchanger connected into its feed line so that the amount of blowdown to each boiler may be proportionate to the feed to that boiler.

If blowdown is controlled by hand, one or more heat exchangers may be inserted in the common boiler feed line and the regulating valves on the individual blowdown lines adjusted empirically to suit the load on each boiler. Tests of the boiler water will indicate which valves have been open too wide or not wide enough.

So far, I have discussed only the common methods of removing concentrated solutions from boilers and have outlined some methods of checking results. I must call to your attention, however, that the method of conditioning boiler water has a marked influence on the amount of blowdown required.

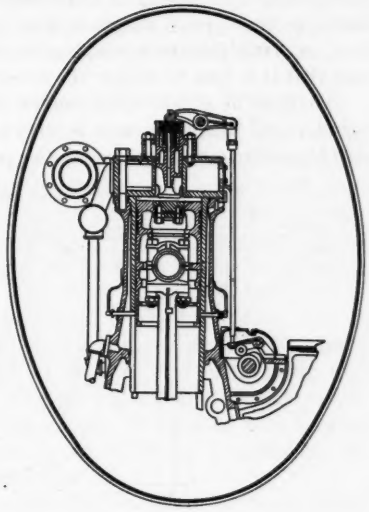
Obviously, boilers fed with only condensate and evaporated makeup require little or no blowdown unless contamination is introduced as by leaky condensers, priming evaporators or in returns from process work due to defective coils, etc.

Equally obviously, boilers fed with water heavily charged with mineral salts will require considerable blowdown. This is equally true if the treatment of a moderately hard water to avoid scale results in a considerable increase in the total dissolved salt content.

At least one manufacturer of equipment has taken advantage of the fact that certain softening methods produce a water which contains considerable sodium bicarbonate. This breaks down to sodium carbonate and then to sodium hydroxide when boiler temperature and pressure are encountered. These two sodium salts (soda ash and caustic soda) are themselves softening agents, capable of precipitating calcium and magnesium salts from raw water as a sludge.

The process is carried out by feeding correct proportions of softened and raw water to the boiler and providing an external settling chamber so connected to the boiler that a constant circulation of boiler water takes place through it, but at such a rate as to permit settling out of sludge which is blown out at suitable intervals. Blowdown is thus reduced to that necessary for the removal of sludge from the settling chamber.

DIESEL ENGINE UPKEEP



PART XI. CHECKING DIESEL-ENGINE VALVE SETTINGS. METHODS OF OBTAINING CRANK DEAD CENTERS AND OF TIMING INLET, EXHAUST AND FUEL VALVES. CONSTRUCTION OF VALVE DIAGRAMS.

BY EDWARD J. KUNZE

WHILE OCCASIONAL checking of Diesel engine valve setting should be a routine part of Diesel engine operation, the setting directed by the builder of the engine should be followed. Tampering operators, who insist on changing settings to suit their whims and fancies give Diesel engine builders more trouble than any other thing. Before making any changes which may appear to be improvements, it is wise, always, to consult the builder or obtain the services of his experts.

DON'T TAMPER WITH ENGINE VALVE SETTINGS

If the original timing was correct for the operating conditions, the exhaust, inlet and starting valve timing requires little attention except that of maintaining the proper roller clearance. Correct timing differs with different engines, hence changes should not be made in the valve setting of one engine because a different setting works well on an engine of another make. Only after years of service should wear of exhaust cams require retiming or replacement. Herein lies the trouble experienced by tampering.

While the mean velocity of the gases through the ports depends upon the piston and valve areas and the mean piston speed, the rapidity and completeness with which a charge will enter and be discharged from the cylinder, which conditions affect the combustion action and the power and efficiency of the engine, are influenced, not only by the size and lift of the valves but also by the shape of the passages around the valves, by the admission pressure and by the smoothness of the admission and discharge.

MANY FACTORS AFFECT VALVE SETTINGS

Relation of discharge to position of valve and to the surrounding passage condition will be appreciated by inspection of Fig. 1 where l is the lift of the valve and d_1 the diameter of the opening above the valve, d_0 and d being the maximum and minimum diameters of the valve disc. It will be seen that after the valve has lifted a certain amount, further lift will not increase the port opening, also that if the space d_1 or the space under the valve is restricted, the fluid friction created when the gases pass around the valve, may be great enough to discount the effect of wide opening of the valve. It will be clear also that the more quickly the valve opens or closes, the shorter, before or after the dead center, is the required time of opening or closing. Characteristic changes in velocity and acceleration which occur during

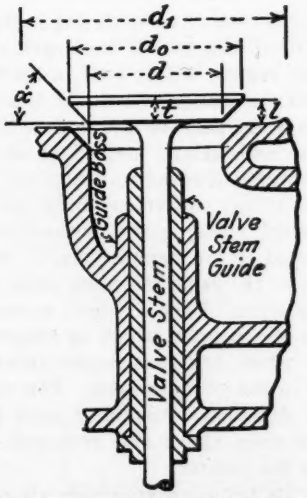


FIG. 1. RELATION OF VALVE AND SEAT AS IT AFFECTS DISCHARGE THROUGH PORT

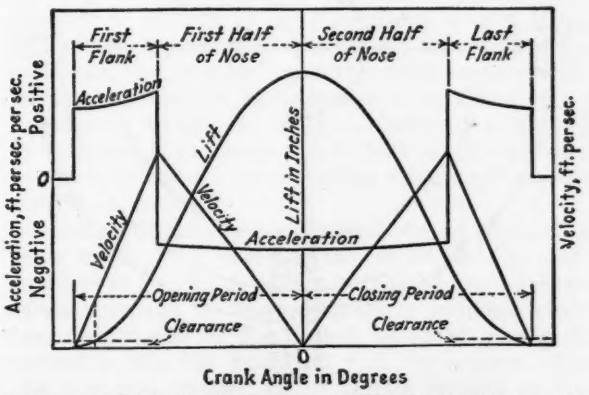


FIG. 2. TYPICAL VALVE DIAGRAM SHOWING CHANGES IN VELOCITY AND ACCELERATION OF ACTION

the opening and closing of a cam-operated valve are illustrated in the typical diagram, Fig. 2. There are, therefore, so many factors governing the valve setting in any case that it is best to follow the directions of the builder.

Analysis of a four-cycle engine valve action as compared to its indicator card is shown in Fig. 3. In this case the outer circle represents the path of the crankpin,

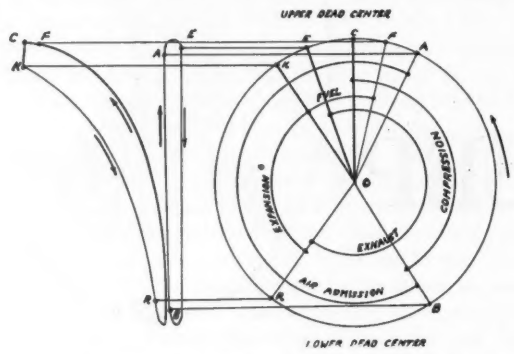


FIG. 3. ANALYSIS OF ENGINE VALVE ACTION AS COMPARED TO IDICATOR CARD

hence two rotations are required to complete the cycle of operations. In order to avoid possible confusion due to indicating events upon a circle which must be traversed twice to complete a cycle, best practice today for four-cycle engines, indicates these events on the camshaft circle which travels half the speed of the crankshaft hence represents 720 deg. of crankshaft movement or four strokes of the engine. Such a diagram is shown in Fig. 4.

For two-cycle engines, since usually, as in crankcase compression, both inlet and exhaust ports are covered and uncovered by the piston hence require no operating mechanism and since timing of such action cannot be

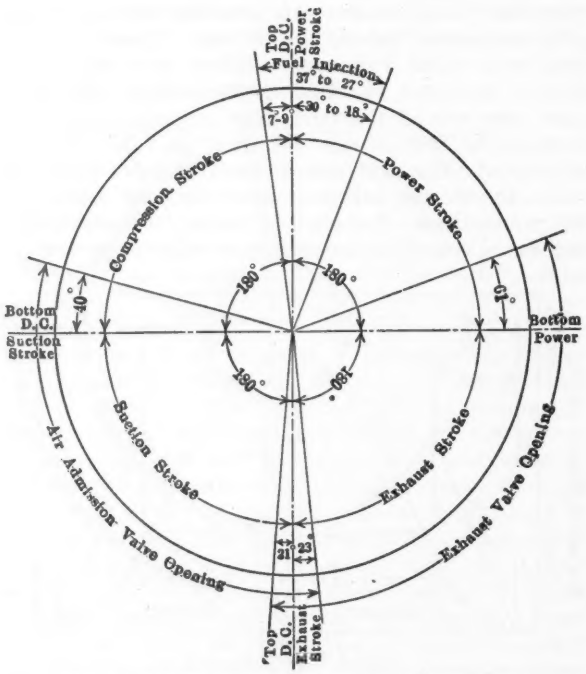


FIG. 4. VALVE TIMING DIAGRAM BASED UPON CAM SHAFT CIRCLE

VALVE SETTING TABLE

ENGINE NO._____ TYPE _____ HAND_____

LOCATION_____

FLYWHEEL DIAMETER_____

VALVE	SPEED OF ENGINE ____ R.P.M. DIRECTION OF ROTATION	1	2	3	4	5	6
FUEL	OPENS BEFORE TOP CENTER						
	CLOSES AFTER TOP CENTER						
	CLEARANCE BETWEEN ROLLER & CAM						
STARTING	OPENS AFTER TOP CENTER						
	CLOSES AFTER TOP CENTER						
	CLEARANCE BETWEEN ROLLER & CAM						
ADMISSION	OPENS BEFORE TOP CENTER						
	CLOSES AFTER BOTTOM CENTER						
	CLEARANCE BETWEEN ROLLER & CAM						
EXHAUST	OPENS BEFORE BOTTOM CENTER						
	CLOSES AFTER TOP CENTER						
	CLEARANCE BETWEEN ROLLER & CAM						

ORDER OF FIRING_____

CYLINDERS, BEARINGS, ETC., ARE NUMBERED BEGINNING WITH NO.1 AT FLYWHEEL END.

FUEL PUMP_____

TOTAL STROKE_____ EFFECTIVE STROKE, MAX ____

FUEL PUMP SETTING_____

NOS. 1—5&6 FINISH DELIVERY _____ IN. AFTER NO. 1 IS IN U.D.C.

NOTE: MEASUREMENTS ARE GIVEN IN INCHES MEASURED ON CIRCUMFERENCE OF FLYWHEEL. SETTING AND CHECKING VALVES TO BE DONE WHEN ENGINE IS COLD. DIRECTION OF ROTATION IS AS SEEN WHEN STANDING AT FLYWHEEL END OF ENGINE AND LOOKING AT THE ENGINE. MEASUREMENTS ARE TAKEN BY MEANS OF AIR WITH FUEL VALVE GEAR IN RUNNING POSITION.

FIG. 5. VALVE SETTING TABLE FORM

changed, the valve action is much simpler but timing of two-cycle-engine fuel valves is required as in all engines.

Valve Setting Range

Although correct timing differs with different engines, in common practice, events usually lie between the following limits: Fuel valves open from 3 to 8 deg. before top dead center and close 35 to 40 deg. after. Exhaust valves open from 30 to 50 deg. before bottom center and close from 10 to 20 deg. after top center. Inlet valves open from 10 to 20 deg. before top center and close from 20 to 40 deg. after bottom center.

Timing diagrams show clearly the relations between events but data concerning valve setting for a particular engine are presented better in tabular form as shown in Fig. 5 for the operating engineer. This presents the checking data in measurements that may be made directly on the flywheel instead of in degrees and offers a convenient method of keeping a record of the original settings with which subsequent checkings may be made readily.

Determination of Dead Centers

First in the process of valve timing is the determination of crank dead centers. If the crank webs are machined and the engine bed is level, a spirit level may be used to find the dead centers. If there are no obstructions, the webs may be squared with the engine bed. The most satisfactory method of obtaining dead centers is illustrated diagrammatically in Fig. 6. The crank is placed at any convenient angle before the dead center and a mark made on the flywheel at a point, A, which is indicated by the trammel bar, T, which must be placed, always at the same reference point on the floor. In this same position of the flywheel, a similar mark is made opposite the pointer which is fastened to block, K, on rod, R, which has been passed through the fuel valve opening in the cylinder head. The engine is then turned in the direction of running until the mark on the rod R has risen above and returned again to coincidence with the pointer.

Care must be taken to approach all points in the direction of running so as to avoid backlash in any part

of the mechanism. If the mark has been passed, the wheel must be turned back a sufficient distance to make up for backlash before moving forward again in the direction of running, to exact coincidence. In this second position the connecting rod will be in the position shown dotted and point B will now coincide with the trammel bar. Now, by dividing the arc A B, the dead

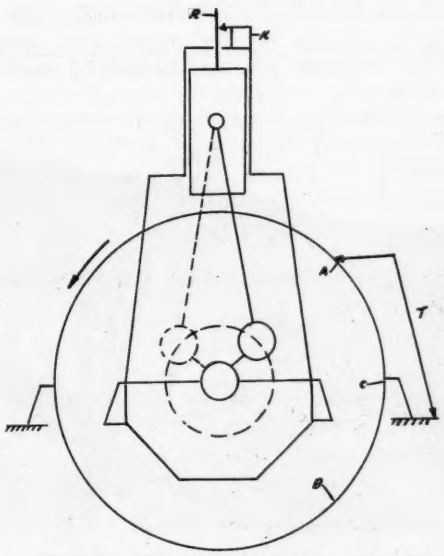


FIG. 6. METHOD OF FINDING CRANK DEAD CENTERS

center C is found. The opposite dead center is determined in a similar manner. If the engine has a crosshead, marks may be made on this crosshead and its guide in a manner similar to that made on rod R with reference to the pointer.

If the original settings are given in inches on the flywheel circumference as indicated in Fig. 5, these distances may be laid out directly on the flywheel. If they are stated in degrees, corresponding distances may be laid out on the flywheel by observing the following:

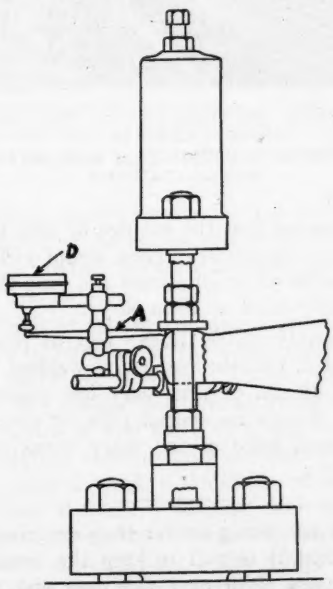


FIG. 7. USE OF DIAL TEST INDICATOR FOR TIMING VALVES

$$1 \text{ deg.} = \text{diameter} \times 3.1416 \div 360$$

In every case, the same trammel bar must be used and the same point on the floor referred to.

Checking Inlet and Exhaust Events

To check the time of opening of the inlet and exhaust valves, the engine may be turned to the points where the rollers come tight on the cams and the crank angle measured, the closing points being those where the cams are freed from the rollers. A more accurate method which is not influenced by backlash in the valve gear is that shown in Fig. 7 in which a dial test indicator, D, shows the slightest movement of the valve stem through contact of arm, A. With some engines, this indicator may be applied without need of the intervening arm. Dial-test indicators register the amount of lift as well as the time of valve movement. Indicators with micrometer attachment reading to 0.001-in. graduations are obtainable in the market.

Correct timing of the fuel value is far more important than that of other valves, one degree difference being enough to have considerable effect upon combus-

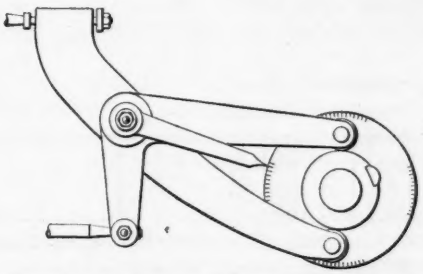


FIG. 8. TIMING VALVES BY USE OF DISC ON CAM SHAFT

tion. Proper lead for the fuel valve, that is the point at which the fuel valve begins to open before the piston reaches its upper dead center, is extremely important for the best operation of the engine.

Accurate Determination by Dial Test Indicator

If a dial-test indicator is not available, the fuel valve setting may be checked by first giving the cam roller its proper clearance, then, after opening the indicator cock or removing it and blocking open an inlet valve, the crank is placed in proper position for the fuel valve to start to open. Now admit air at from 100 to 200-lb. pressure and turn the engine over slowly in the regular direction of rotation. When air emission is heard at the indicator cock opening or with the ear held close to the air-intake pipe, stop turning. This point represents the position at which the valve starts to open, therefore the distance on the flywheel rim from this point as marked by the trammel bar, to the upper dead center point may be measured and the corresponding crank angle may be secured, if required.

Instead of marking the positions on the flywheel, a brass disk may be placed on the end of the cam shaft as shown in Fig. 8. A pointer is fastened to the rocker-fulcrum pin and the crank dead center positions, which have been found by the method indicated in Fig. 8, marked on the disc coincident with the pointer. The disc then may be laid out in degrees through an arc covered by the firing period. A set of such marks would

be required for each cylinder of the engine. Since the camshaft runs in a 1 to 2 ratio, there never is a question regarding whether the piston is on the firing or suction dead center.

If the fuel cam has been displaced less than two or three degrees, the timing may be corrected in some cases by increasing or decreasing the cam clearance. This is done by giving more or less clearance to the tappet bolts on the rocker arm. This method cannot be used, however, for greater displacements as it affects the lift of the valve.

Movable Cam Adjustment of Timing

Fuel valve setting is accomplished much better by adjustment of the nose of the fuel cam. Two methods

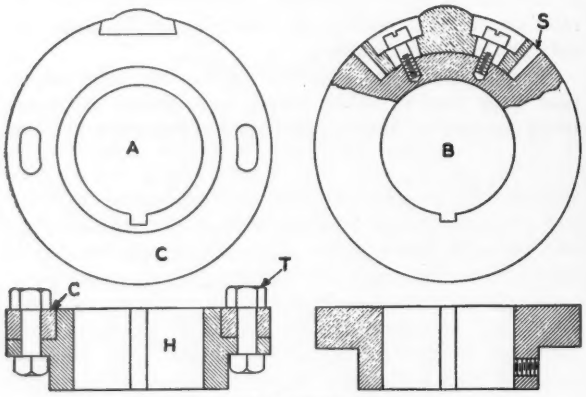


FIG. 9. TYPES OF ADJUSTABLE FUEL CAMS

of doing this are illustrated in Fig. 9. In the first case, A, the hub flange, H, is keyed to the camshaft. The cam flange, C, whose nose is fastened permanently to it, fits on the hub of H with a sliding fit and is slotted to permit of adjustment movement after which it is held in its set position by means of bolts, T. The other adjustable cam, B, has a movable nose block which is slotted on each side to permit movement when the fastening screws are released. To adjust the position of the cam nose, shims of metal placed at S are moved from one side of the nose to the other and the screws retightened.

86,000-Ft. Pipe Line

UP HILL AND DOWN, across valleys and through tunnels, runs the pipe to carry water from Otay reservoir to San Diego, Calif. It is of steel pipe 36 and 40 in. diameter, thickness varying from $\frac{5}{16}$ to $\frac{3}{8}$ in. and is joined up by bell and spigot joints, electrically welded both inside and outside.

Lengths of pipe, made by the Western Pipe & Steel Co., were mostly 30 ft. but varied according to the terrain. Lengths were lined up and welded into sections as most convenient, then tied into the main line. For tunnels, the welding was done outside, then the sections rolled in as shown in Fig. 1.

This line, which has a capacity of 17,000,000 gal. a day by gravity and 25,000,000 gal. a day with booster pumps, which will be installed later, replaces a wood-stave line of 10,000,000 gal. a day capacity, installed in 1901. A section of the old line is seen in Fig. 2, also a section of the new line under construction.

Tunnels, the longest 2150 ft., were cut through four hills, the dimensions being 6½ ft. high by 6 ft. wide, giving ample room for handling the pipe.

For protection, the pipe was dipped in hot asphaltum and the sections outside the tunnels were wrapped with a special felt.

Numerous horizontal and vertical angles, due to the irregularities of the country passed over, made the welded line the most practical method of construction

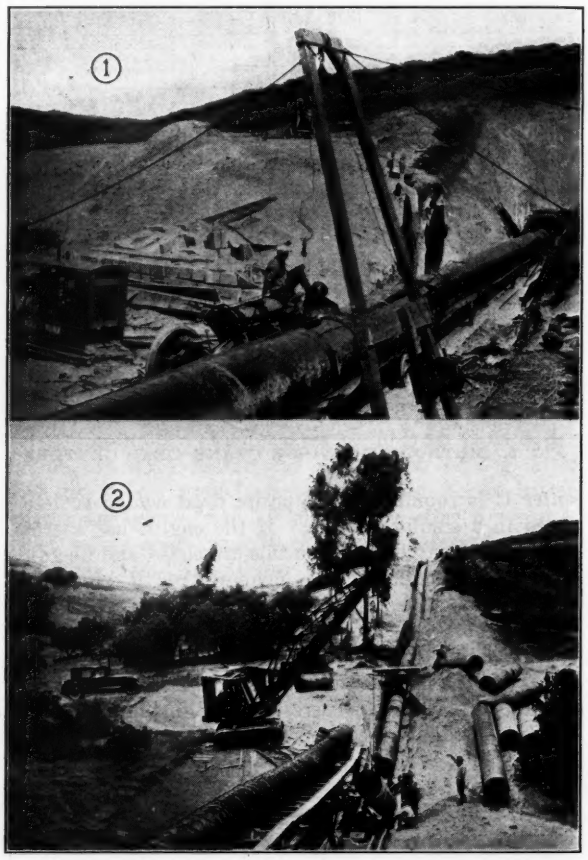


FIG. 1. TUNNEL SECTIONS WERE WELDED OUTSIDE THEN ROLLED IN
FIG. 2. DIFFICULT CONSTRUCTION WAS INVOLVED OVER ROUGH COUNTRY

but it is estimated that the savings by this method savings, placed at compound interest would yield in 12 yr. an amount sufficient to duplicate the pipe line, the life of which is calculated as 40 to 50 yr.

Approximately 86,000 linear feet of pipe line was thus arc welded, Lincoln Stable-Arc welders being used. In a test of 10 mi. of line, only one major leak was found, even though no special pipe or special precautions were used, spite of the sharp turns and uneven ground.

Ammonia gas, being lighter than air, rises so that in case of accident it is well to keep the head as low as possible. A wet cloth over the nose and mouth will absorb ammonia and prevent inhalation.

Helical Grooves in

COMMUTATORS *and* SLIP RINGS ELIMINATE BRUSH TROUBLES

The idea presented in this article is so simple and its application so logical that it leads one to wonder why it had not been tried before. Ever since direct-current machines were first used, the problem of commutation and brush maintenance has been a serious one but not until now has anything been produced which so effectively solves this problem. Every operator of electrical machinery should be interested in this article.

AT THE RECENT winter convention of the American Institute of Electrical Engineers in New York, there was presented an exceedingly interesting paper dealing with the operation and performance of brushes on commutators and slip rings. This paper which was presented by G. M. Little, research engineer of the Westinghouse Electric & Manufacturing Co. was of interest because the researches it describes seems to offer an effective solution to one of the most troublesome and discouraging problems encountered in the operation of large rotating direct-current equipment, although their application is by no means limited to direct-current work.

Brushes have always given more or less trouble in d.c. machine operation and while it was recognized that many of the difficulties were due to purely mechanical features such as loose bars, worn bearings, dirt, oil, etc., all of which could be eliminated, there were also a number of obscure factors, not so well understood, which affect brush performance. Even when all the usual mechanical conditions are satisfactory there are still difficulties in transmitting current between the brushes and the commutator or slip rings. Usually it is found that the current does not divide equally between parallel connected brushes resulting in overloading of some of them.

Mr. Little's paper presents the results of an investigation of some of the causes of the trouble that exists at the sliding contact between a brush and a rotating slip ring or commutator.

Much is said in this article about overloads and the concentration of current, at the brush face, into one or more spots which get very hot. It is a most plausible supposition that under the normal running condition of a brush, which is well fitted to a slip ring (or commutator), that the current flows across the sliding contract at all times through a multitude of tiny contacts distributed over the entire polished face of the brush. There is good evidence that this is only partly so. It is shown that with a well fitting brush riding on a smooth slip ring, there is only a comparatively small number of minute contact points or groups of points concerned in carrying the current, at any given instant. Under light pressure there may be from 3 to 6 active current carrying spots, while under increased pressure, 50 to 100 spots may be shown to be active.

The demonstration consisted in discharging a large condenser across the contact between the brush and the slip ring. This discharge, estimated to be at least 3000 amp. was over in only a few millionths of a second, and was so rapid that, though the slip ring was revolving at 1500 r.p.m., the pattern burned on the face of the ring and on the face of the brush consisted of a group of well defined minute spots, and the distribution of these spots over the brush face was found never to be the same in successive experiments. These spots constitute less than three per cent of the total area of the polished brush face.

It is probable that under normal running operating conditions the current at each successive instant of time finds a different group of contact spots to carry it across the sliding contact. These groups shift around with incredible rapidity as was shown by a method suggested by R. M. Baker, who proposed the use of a double filament oscillograph to record simultaneously but separately the current flowing through the two halves of a divided brush. In the oscillogram, the current is seen in some instances to drop to zero in one half while at the same instant the other half is seen to be carrying all of the load.

It was observed that if the current density was very high, a brush was likely to glow and throw off white hot streamers. This glowing manifested itself as a small stationary or slow moving white hot spot in the polished surface of the brush. This, of course, could not be seen directly but it heated the surrounding brush material for ⅛ in. in all directions to a good red color and if the small white hot spot was near to the edge of the brush the red glow of the surrounding brush material was readily seen.

A study of this glowing confirmed in the writer's mind the correctness of the usual explanation of the cause which was based on the negative temperature coefficient of carbon. If a brush is overloaded and one part of the brush face should by chance be a little warmer than another part, the current will tend to crowd into this warmer area, raising its temperature more and more until a low resistance hot spot is developed, which then carries substantially all of the current.

It was observed that a hot spot of this kind will remain in one location on the brush face for many hundred revolutions of a commutator or slip ring, during which time all sparking of the brush will be stopped. This tendency of a spot to take all the current and to hold to one position on the brush face is further promoted by the local expansion of the hot carbon. This

expansion causes the hot spot to become slightly raised above the polished level surface and the brush rides on this "hill" until it is worn down. During this time, most of the spring pressure is concentrated on the minute raised area. The local temperature rise due to friction in thus probably a large contributing cause for bringing about the stationary hot spot condition.

A convincing observation of this action was made on a badly overloaded glowing brush riding on a slip ring. The expansion at the hot spot was so great that it raised the brush off of the slip ring noticeably and it was possible to see through the gaps on either side of the hill.

Figure 1 shows the surface of a carbon brush that had been glowing. The light colored spots, around which are seen semi-circular cracks, show where the current had concentrated. This had raised the local temperature so high that it had changed the dark colored carbon into the lighter colored graphite.

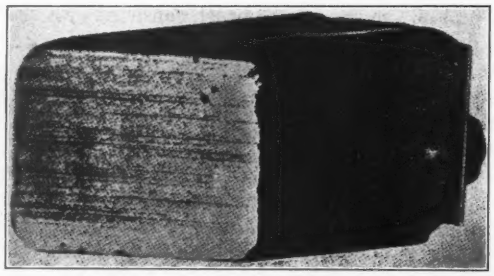


FIG. 1. FACE OF A BRUSH THAT HAD BEEN "GLOWING" AND THROWING OFF "STREAMERS"

Note the light colored graphite spots, the semi-circular cracks and the black cavities produced when a graphitized spot falls out.

When the cracks go clear around, a little white hot semi-spherical particle falls out and is thrown off by the rapid rotation as a brilliant streamer.

Narrow crosswise grooves in the surface of a rotating commutator, produced by undercutting the mica, are not able to break this up, because a hot spot has sufficient area that it can bridge the small gaps without interference to the current flow; also, if the current was broken, there would not be enough time for a spot to cool appreciably before it again made contact. When a brush is badly overloaded, the hot spot temperatures may rise to 2000 deg. C., sufficient to graphitize the minute areas affected.

With these observations in mind, it occurred to the writer that if the current passing through the hot spot could be blocked and some other portion of the brush face, or even another parallel connected brush, could be forced to take the load for a portion of each revolution of the commutator, during which period the hot spot would have an appreciable time to cool; perhaps a more uniform distribution of current under the brush face and between parallel connected brushes would result, together with an absence of local spot heating and glowing.

Two schemes were evolved, (1) a row of side-by-side straight around, offset grooves (see Fig. 2) and the helical groove (see Fig. 3). Both schemes were tried and gave similar results but the helical groove was easier and cheaper to make and could, if necessary, be cleaned more readily. In both schemes a given spot on the face of the brush can carry current and be subjected to frictional heating for only a portion of each revolution of the slip ring or commutator, during which time some other spot or group of spots is forced to carry the load. Any air trapped under the brush face which is a contributing factor in uneven current distribution is permitted to escape as are any loose abrasive, solid particles of brush or ring material. Some years ago Messrs. Shand, Wagner and Eschholz demonstrated that, in the case of parallel-connected metal graphite brushes running on a slip ring, air was trapped under the brush face. This was illustrated by drilling a hole down through the brush and connecting it to a manometer tube; 8 or 10 in. of water pressure was sometimes found.

Tests showed that the helical groove improved the performance of brushes on a slip ring very much. It is not at all unusual on a commercial slip ring to find that practically all of the current is being carried, by only one or two brushes out of a set of five or more connected in parallel.

Tests were then made to determine what effect grooving a slip ring had on the contact resistance. Use was made of two copper slip rings, one plain and one grooved, mounted on the same shaft. Each was equipped with one positive and one negative brush and the rings were so arranged that they could be operated either in series or in parallel.

At the start, with clean and papered rings and brushes, the contact resistance on both the rings was extremely low but the grooved ring brush contact was almost always much lower than that of the plain ring. The resistance of both rings then slowly rose, until finally the resistance of the grooved ring and brushes became about 20 per cent higher than that of the plain ring and its brushes; this sometimes took 20 or 30 hr.

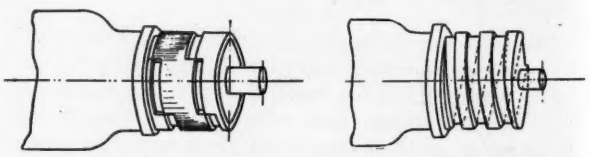


FIG. 2 FIG. 3

FIG. 2. THE "STRAIGHT AROUND" OFFSET GROOVE
FIG. 3. THE HELICAL GROOVE

At the beginning of this test, it would appear that no film or polish having a high resistance was present and the bare surface of the grooved ring had the lower contact resistance even though the available contact area was much smaller, because the pressure per square inch exerted by the spring on this smaller area was raised, in this particular instance, to about three times that on the plain ring. As the test proceeded, there was apparently a very slowly formed high resistance film or polish, on the sliding surfaces, and this film on the grooved ring and its brushes finally became higher in resistance than that which formed on the plain ring and its brushes. With certain brushes, (such as Stackpole L21) running on a plain and a grooved ring connected in parallel and supplied with a constant current it was usual to find, after the day's run, that the worn grooved ring has the higher resistance and was taking only 5 amperes while the worn plain ring was taking 10 amperes. On shutting down for the night and starting again in the morning, cold, both rings were found to have acquired a very high resistance, and usually the

grooved ring was initially the lower of the two. This grooved ring would start off with ten amperes while the plain one took only five. This condition often lasted for hours though finally a return to the former state always occurred as the rings became worn.

While the difference in character, between the slowly formed film of the grooved ring, from that on a plain ring is probably the main reason for the difference in the contact resistance (the 20 per cent increase), there is another well demonstrated cause:

An oscillograph shows that on a plain ring a sudden forced increase in current density at the contact between a brush and a ring causes a large, but rapidly diminishing, increase in the contact resistance (see Fig. 4).

It would appear that with a suddenly applied current an appreciable time is required for the temperatures of the current carrying contact spots to rise, during which time the resistance (owing to the negative temperature coefficient) remains comparatively high. The helical groove scheme furnishes means of control whereby the duration of time that any given spot on a brush face can carry a heating current and maintain frictional contact may be limited to 0.02 sec. or less; and from an inspection of the oscillogram as given in Fig. 4, it appears reasonable to believe that this should result in an increase in the contact resistance.

This temperature lag effect on the resistance of the sliding brush contact is shown if a 25-cycle a.c. current is used. The repeated changes from 0 to the maximum current value and back occur so quickly that the temperature of the current carrying contact points does not change appreciably and as a consequence the voltage and current are in phase and the resistance remains constant, as is shown by an oscillogram in Fig. 5. This is further confirmed by slowing down the frequency so much (to three cycles per minute) that a very appreciable period of time lapses while the current is passing through one cycle. The oscillogram then shows that the voltage curve is distorted and the resistance changes enormously, as in Fig. 6, as the current values slowly change.

Laboratory Tests on Slip Rings

A test[1] of five parallel connected, metal graphite brushes on a plain bronze slip ring gave frequent exhibitions of one or two brushes taking all of the current, while later the same brushes run on a grooved ring were free from this trouble.

Another test showed that with a grooved and a plain ring in series and with only one brush on each ring, the plain ring brush sparked badly, the grooved ring brush operated perfectly, while the set was subjected to a heavy overload.

Laboratory Tests of the Helical Groove on Commutators

The laboratory investigation of the application of a helical groove to a commutator has disclosed some interesting information.

One of the first trials was made on a defective d.c. 2000-amp., 500-v. generator.

This machine would carry ½ or ¾ load very satisfactorily but on full load trouble would develop in a few hours time and on load and a half, the glowing, sparking and streamers would develop within 10 min.

After the commutator was grooved ⅜-in. pitch, ⅛-in. groove, the machine carried full load indefinitely (over a week) with no glowing and stood the 50 per cent overload for 3 hr.; also, it was noted the grooved commutator ran 10 deg. C. cooler than the plain commutator. Later, this same grooved commutator machine was operated at full load and 8 out of the 44 brushes were removed; no distress was observed. This suggested the possibility of building shorter and less expensive commutators.

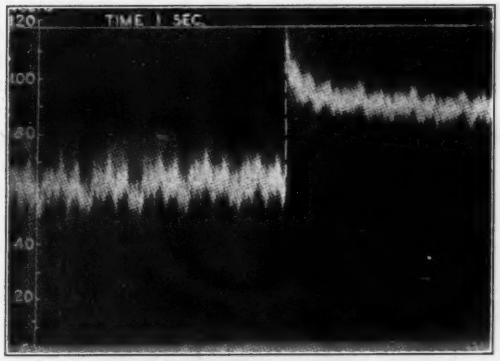


FIG. 4. VOLTAGE CHANGE ON A PLAIN SLIP RING AS CURRENT IS SUDDENLY STEPPED UP FROM 1 TO 7 AMP.
Note that the voltage is very high during the first 50th of a sec. By means of the helical groove the current carrying time of a given spot can be limited to less than 1/50 sec. This keeps the temperature down and the resistance up, giving a desirable higher contact drop.

A long (200-hr.) test on a plain, and later, grooved ⅛-in. ridge, ⅛-in. groove d.c. traction motor, 40-amp., 500-v., gave an improvement in sparking at 7 deg. lower commutator operating temperature and left the commutator in better condition at the end of the test. The current distribution between the parallel connected brushes was more even.

One odd and possibly useful feature of the helical groove is that, if sparking occurs at one spot only in the revolution of the commutator, e.g., at a high or a low bar or a flat, the fact is shown by the formation of a peculiar pattern burnt on the face of the brush and this can serve to locate the offending bar by rotating the commutator until the burned pattern rests accurately on the ridge. This is illustrated in Fig. 7.

It appeared from the above data that grooving a

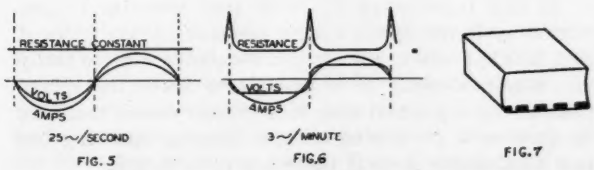


FIG. 5. CURVE (FROM OSCILLOGRAM) SHOWING THAT RAPID RECURRING FLUCTUATIONS IN CURRENT DENSITY ARE NOT FOLLOWED BY FLUCTUATIONS IN TEMPERATURE AND RESISTANCE

FIG. 6. CURVE (FROM OSCILLOGRAM) SHOWING THAT SLOW RECURRING FLUCTUATIONS IN CURRENT DENSITY ARE FOLLOWED BY CORRESPONDING CHANGES IN TEMPERATURE AND RESISTANCE

FIG. 7. PATTERN BURNED ON A BRUSH FACE IF THERE IS SPARKING AT ONE SPOT ON A GROOVED COMMUTATOR, E.G., AT A HIGH BAR

[1]Taken at the laboratory of the Stackpole Carbon Co.

commutator probably does much more than simply prevent the formation of hot spots.

Cooler operation suggested that the wasteful circulating current that occurs under a brush face during ordinary commutation had probably been reduced and this could be explained only by supposing that in some way the contact resistance had been raised.

Depth of the groove has little or no effect on the performance, though it is reasonable to expect that a deep groove might promote cooler operating, due to the increased radiating surface and the larger amount of cooling air that is dragged across the brush face.

Width of the groove and the pitch of the thread are being studied and it would appear that to secure the best results in different kinds of service, these dimensions will be varied considerably.

When a helical groove is cut in a commutator or slip ring, the available sliding contact area is reduced and

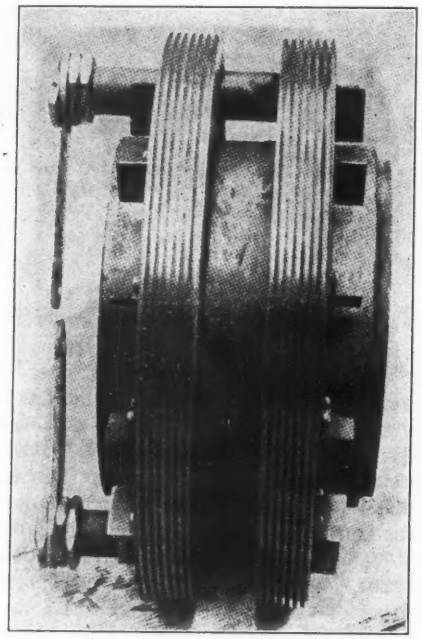


FIG. 8. GROOVED SLIP RINGS ON TWO 13,000-AMP. SYNCHRONOUS CONDENSERS. THESE MACHINES ARE IN COMMERCIAL SERVICE WITH THE SOUTHERN CALIFORNIA EDISON CO.

with no change in the spring pressure, the pressure per unit area is raised.

If this increase in the unit area pressure is prevented by lowering the spring pressure on the grooved ring brush, a rise in the contact resistance is more easily and surely shown. It is possible to lower the spring pressure on a grooved ring to a greater extent than can be done on a plain ring without causing sparking but this must not be done if there is any vibration.

The appearance presented by a grooved commutator while it is rotating conveys an impression that there must be a powerful action tending to drag the brushes toward one end of the shaft but no such tendency exists as the brushes slide on the tops of the ridges.

When grooving a commutator, it is very desirable to stone the surface after the groove has been cut in and the edges slightly rounded, as any burr left is disastrous to brush life and sandpapering alone is not effective. For subsequent polishing, a very fine sandpaper backed by a wooden block is best.

Commercial Applications to Slip Rings

The above slip ring tests were so convincing that when the information was given to one of the public service companies, they decided to coöperate in an experiment on the rings of one of their 13,000-amp. rotary converters. The operation was so satisfactory that they are now having another machine grooved and put into service. Another public service company is putting in operation, a large synchronous condenser equipped with hydrogen enclosed steel slip rings with helical grooved surfaces.

Figure 8 shows a ⅛-in. wide groove, ⅛-in. wide ridge, ½-in. pitch ring for a 15,000-kv-a. synchronous condenser.

Outdoor 1450-lb. 825-deg. Boilers Planned for Herndon Project

AT HERNDON, Calif., on the San Joaquin River, the San Joaquin Light & Power Corp. is planning the erection of a new 50,000-kw. steam power station according to a recent announcement by the company. Preliminary work is being done to prepare the site for the erection of the plant, but there will be no actual plant building done this year.

According to present plans, the plant is to be housed in three buildings, one containing the turbine and generators, one containing transformer un-tanking equipment, and one housing the offices and control boards. The boilers will be out of doors. The plant will burn natural gas as fuel, the boilers operating at 1450 lb. pressure at a total steam temperature of 825 deg. F. It is expected that the plant will cost about $4,500,000. The waters of the San Joaquin River will be used for cooling and condensing purposes.

The site at Herndon, which is 10 mi. north of Fresno, Calif., is approximately at the center of the company's distribution system and the probable scene of the greatest growth of business in the next few years.

The plant will be double the size of the next largest steam plant on the San Joaquin system, that at Buttonwillow, which has a capacity of 25,000 kw. The Bakersfield plant has a capacity of 24,500 kw.

The work at Herndon is to be under the supervision of Harold K. Fox, chief construction engineer, who superintended construction of the Balch power plant on Kings River for the San Joaquin Light & Power Corp. and more recently the steam generating plant of the Great Western Power Co. at India Basin, San Francisco.

Extensive development is planned at the Herndon site where a substation is to be built immediately to strengthen the tie-in of the San Joaquin and P. G. and E. systems. New high-voltage transmission lines will connect this substation with Wilson substation near Merced on the north and Corcoran substation on the south. Existing transmission lines supplying the northern end of the San Joaquin Valley will be tied into this station.

In Belgium, coals from various sources are blended under close chemical control to give the best economy.

Value of Insulation Resistance Tests

RECORDS SHOW DETRIMENTAL EFFECT OF ACCUMULATED OIL. BY M. TERESINSKI

FEW MEN ENTRUSTED with the care of electrical machinery understand how, due to the accumulation of dirt and oil, the resistance of the insulation has a tendency to vary, this in spite of the importance of such knowledge. In fact, in no few instances it has been found that by checking up periodically the insulation resistance of the windings of motors and generators,

FIG. 1. MEGGER TEST SET FOR MEASURING INSULATION RESISTANCE

breakdowns can almost be pre-determined to a day. Of course, if checks are to be made on the insulation resistance it would be obviously foolish to allow the continued accumulation of dirt and oil to reach a point such as would invite breakdown. By means of such periodic checks, however, these breakdowns can be eliminated and avoided.

One of the most useful instruments in the hands of the maintenance electrician is that called a Megger, such as illustrated in Fig. 1 and by means of which the resistance of insulation may be instantaneously determined by merely rotating the handle. The record of the use of such an instrument is most interesting. Referring to Fig. 2, we find the effect which accumulated dirt and dust had upon the insulation resistance of a 100-kw. rotary converter. Checks on this unit were made weekly and as will be noted, before cleaning the insulation resistance invariably had dropped appreciably. In fact, in a number of instances as will be observed this drop became almost dangerous.

Use of the instrument was started in December, 1929, the readings being taken before and after cleaning of the windings. The effect of cleaning is quite evident but not as much as that of both cleaning and repainting. This took place on May 31st, 1930, at which time the insulation resistance had dropped to 100,000 ohms. Immediately, however, after the unit had been cleaned and the windings repainted with insulating varnish the resistance was brought up to 10 meghoms and after which time, as will be observed, the resistance of the insulation in general remained comparatively higher than previous to the time of painting.

Figure 3 illustrates graphically the variations in insulation resistance of the windings of a 3-t. crane magnet. As will be noted, the continued drop in resistance occurred between the first of March and the middle of June, at which time a minimum of 5000 ohms was reached and also at which time it was discovered that the magnet was becoming weak. Repairs were made in

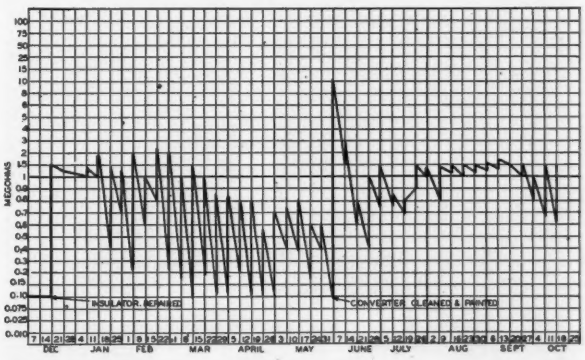


FIG. 2. RECORD OF THE INSULATION RESISTANCE OF A 100-KW. ROTARY CONVERTER

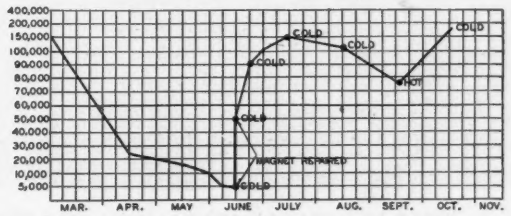


FIG. 3. RECORD OF THE INSULATION RESISTANCE OF A CRANE LIFTING MAGNET

a way of replacing some of the insulation, cleaning the windings and repainting the whole. After this the insulation resistance at once increased, first to 30,000 ohms and then gradually as the insulating varnish became more impregated and harder this resistance reached a maximum of 150,000 ohms.

A FLEXIBLE COUPLING should always be used between a centrifugal pump and its prime mover, whether that be an electric motor, steam turbine, steam engine, or water turbine, and even with heavy belt drives. This is to keep slight misadjustments caused by distortion of the bed plate or piping strains from being transmitted from one unit to the other and causing vibration, springing of the shaft or damage to the bearings. The fact that this flexible coupling is there, however, does not mean that the unit should not be lined up as closely as possible.

UNPROFITABLE eloquence is like the cypress; great and tall but bears no fruit.

Architecture as a Factor in Plant Design

CARE IN THE SELECTION OF PROPER MATERIALS AND CAREFUL, CONSERVATIVE DESIGN GIVE PLANTS THAT ARE PRACTICAL, BEAUTIFUL AND ECONOMICAL. NEW AND DISTINCT TYPE OF ARCHITECTURE WITH STRAIGHT PERPENDICULAR LINES, PILASTERS AND DEEP REVEALS GIVE DESIRED EFFECT BY MEANS OF SHADES AND SHADOWS. BY W. R. FARGO*

ARCHITECTURE, taken literally, may be construed to mean the design and decoration of any sort of structure to beautify it and make it more pleasing to the eye. Architecture as applied to power stations is

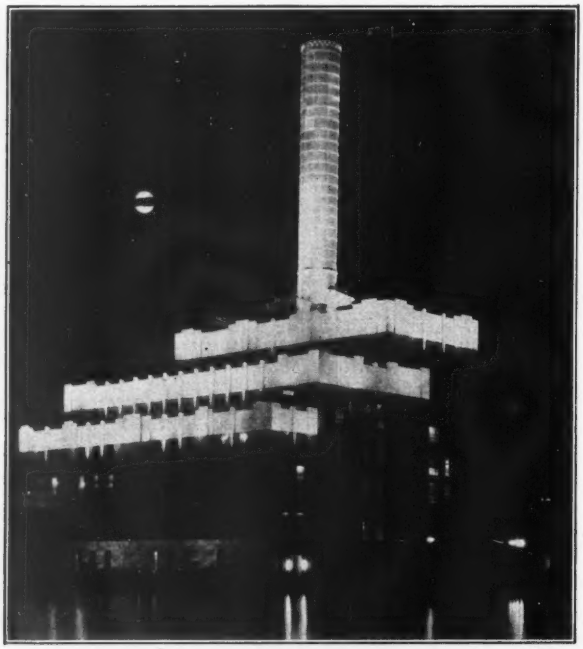


FIG. 1. BELLE ISLE STATION AT OKLAHOMA CITY WHERE DESIGN DETAILS ARE UNUSUALLY IMPORTANT BECAUSE OF THE GREAT NUMBER OF VISITORS AND ITS PROXIMITY TO THE CITY

necessarily confined more to materials which lend themselves to treatment rather than the use of a lot of ornamentation, which would not only be expensive but impractical for this type of building.

Exterior designs of the Belle Isle, Granite Falls and Coos Bay Stations are so different that they make an excellent subject for a discussion of this kind. In the Belle Isle Station there were a great many favorable factors in preparing the design, most important being the location close to Oklahoma City, and a necessity for different exterior treatment from anything we have ever done, because of the possibility of a number of people visiting this station and the great distance from which it will be visible. In this design, the type of architecture was carried out which lately has been named by Cass Gilbert, one of the noted architects, as "perpendicular Gothic." The term as applied in this particular case relates, of course, to the perpendicular lines which were carried throughout the building and the deep reveals which were obtained by the use of extra heavy walls and a number of wide pilasters. The materials used on this building were selected with the idea of contrast in color, the brick being gunmetal and the stone white.

Due to the limited appropriation set aside for the Minnesota Valley Steam Electric Plant, it was necessary to hold the design down as much as possible as regards expense. Therefore, ornamentation was confined to the use of a few pilasters on the exterior and dependence on the color and qualities of the materials to give a building which would be pleasing and still not expensive. The contrast will be accomplished by the use of a deep red brick and a grey Indiana limestone.

The Coos Bay Station is an example of strictest economy in design and materials and very little can be said from an architectural standpoint. Here is a building of four walls with a floated cement finish, depending on a few pilasters treated with colored ornamental tile to break up the plainness. The location of this plant made it unnecessary to spend a great amount of money on the exterior.

As to the kinds of materials which lend themselves readily to treatment in various forms to obtain architectural effects, the most important is the use of stone for base courses, copings, pilaster bases and caps and entrances. By the use of stone backed up by brick instead of concrete, an actual saving has been effected over the old method of building concrete walls 10 to 14 ft. above grade and the stone is a much more durable and lasting material. The fact that it does not discolor and become blotchy with age is enough in itself to justify its use in the various stations. The selection of face brick for exterior purposes for color in getting a pleasing contrast with the other materials and surroundings cannot be over-stressed and the little time spent in careful study of their selection is well worth while. We have found that generally a brick of a solid color laid up with dark joints gives a much more pleasing wall than the variegated colors, because unless the mason is extremely careful in mixing these various shades, there is a tendency to get spots where too many bricks of either the light or dark shades are run together.

TREATMENT OF INTERIOR

From an architectural viewpoint, the most important part of these various plants is the interior. Regardless of how beautiful and substantial the building might be on the exterior, this effect is entirely lost if sufficient time is not spent on the selection and proper use of the materials throughout the various portions of the building. It was with this in mind on the Belle Isle Plant that Zenitherm was used, a material which is made of wood pulp put under a tremendous pressure and coming

*Architectural Designer, Byllesby Eng. & Mgt. Corp., Chicago, Ill. From a paper presented at a convention of the Engineering Department of the Byllesby Eng. & Mgt. Corp.

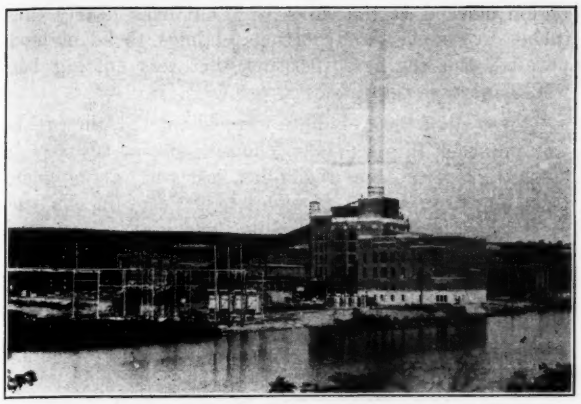


FIG. 2. MINNESOTA VALLEY STATION AT GRANITE FALLS, MINN., WHERE COLOR AND QUALITIES OF MATERIALS HAVE BEEN DEPENDED UPON TO GIVE A PLEASING APPEARANCE

in range of beautiful colors, for the entrance lobby. The walls of this entrance lobby will be buff and gold, with a grey ceiling and heavy exposed false wooden beams finished in a dark mahogany color. The floor will be terrazzo laid off in squares with brass strips and should lend a pleasing contrast to the side walls and ceilings of this room. Upon entering the station, a visitor's first impression will be formed from this entrance lobby, and as first impressions are always lasting ones, this room will be remembered when the rest of the station is forgotten.

On the Minnesota Valley and Coos Bay Station, however, no opportunity was afforded to use these materials, therefore, we had to confine ourselves to the use of quarry tile and brick.

The next portion of the building to be considered is the turbine room and this particular section has always been given a great deal of study in selecting materials which were substantial and at the same time easy to keep clean. Probably no part of the building attracts as much attention as the turbine room, since a non-technical person is generally attracted to this portion of the plant because of the attractiveness of the equipment housed therein. Turbine rooms in these three stations are lined with a semi-glazed washable brick of buff and brown shades, the brown being used as a continuous six-foot wainscot around the room and the buff from there to the roof. The crane columns are generally surrounded with a brick pilaster, using the dark brown brick of the same shade as the wainscot directly under the crane rail to form an ornamental cap and a backing for the lighting fixtures, one of which is generally installed on each of these pilasters. The important factor in considering the shades of this brick is not to get it too dark, as the light in turbine rooms is generally limited and is easily cut down by dark walls. The floors in these turbine rooms generally consist of nine by nine quarry tile of a red shade laid up in natural joints, giving a substantial and pleasing floor.

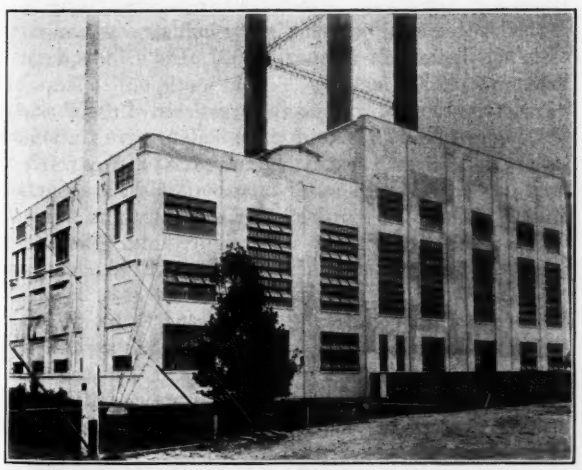


FIG. 3. THE COOS BAY STATION AT MARSHFIELD, ORE. AN EXAMPLE OF STRICT ECONOMY

In the Belle Isle and Minneosta Valley stations, domestic instead of imported quarry tile, which has been our standard for a number of years, is being used; extensive tests have shown that there is no difference in the quality of the two and the domestic can be furnished and installed for practically half the amount formerly paid for imported Welsh tile.

Walls in the electric galleries are generally of semi-glazed brick of the same quality and color used in the turbine room, and the floors are either tile or have a colored concrete hardener. Toilet room walls are of this same brick, the floors being of terrazzo because of its long wearing qualities and acid resistance.

In the boiler rooms, the salt glazed brick is also used and the operating floors consist either of hardened concrete or quarry tile, in accordance with the wishes of the various operating companies.

All of the doors throughout these three stations, with the exception of the railway track entrances, are of the hollow metal type and bear the underwriters' label. The large track doors are either wood or steel rolling doors. this being left to the discretion of the operating department. The location of the station is always taken into consideration in this selection.

Progress in Power House Design

Substantial steps forward have been made in power house design in the last few years, especially in relation to the standardization and use of the abovementioned materials. We are continually investigating new materials as they are being called to our attention, and it is only after thorough investigation that we have deviated from our standards to use a new material.

Architectural design in power plants and industrial buildings will turn more and more to the more modern type of architecture, because of its adaptability and usefulness in these types of buildings. It has always been the practice among industrial architects, because of economy, to make these buildings as plain as possible, insofar as ornamentation is concerned, and the only alternative in developing a new and distinct type of architecture is to go to straight perpendicular lines, carrying out whatever effects are desired by means of pilasters and deep reveals, thereby getting the desired effects by means of shades and shadows.

As time goes on, more and more care will be exercised in the selection of proper materials and this together with conservative design along the above lines, will give us plants which are practical, beautiful and economical.

Hydroelectric Plant Output Increased 23 Per Cent

DETAILS OF CHANGES THAT INCREASED OUTPUT AND EFFICIENCY. BY JOHN S. CARPENTER

SOME TIME AGO, a two-unit water turbine plant was put in under contract conditions but just about when everything was ready to start, legal obstacles intervened. It was some time before the legal matters were settled and then it was found that the head would be materially lower than contract conditions called for. As a standard turbine had been bought and litigation had drained funds so that radical changes could not be made, it was decided to make a test of efficiency and output and see what could be done. A weir test under the new conditions gave the results shown by the solid line in the curve, Fig. 1. These were discouraging.

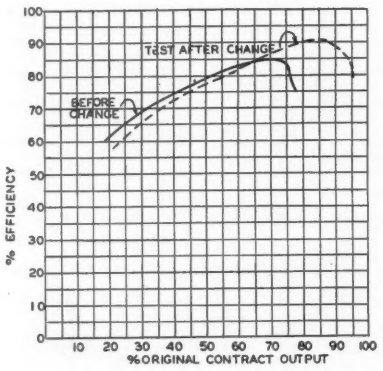


FIG. 1. TEST CURVES SHOWING HOW CHANGES INCREASED OUTPUT AND EFFICIENCY

The builder produced an expected performance curve showing what he thought could be done by certain changes but would not guarantee results. The offer was not considered on account of the cost. Others proposed to tear out the whole turbine and replace it with a new one.

At that time, an hydraulic engineer was found who was known as a good runner designer and who was also known to have much testing laboratory experience. He offered to make certain changes, after an inspection of the turbine, for a cost much lower than the cost of any other proposal. On account of his limited personal finances, he could not make any guarantee but after several conferences with the power company engineer the worth of his ideas was confirmed and work was started.

As will be noted at A in Fig. 2, there is a rather sharp turn that obviously causes friction that could have been avoided. Plate B was taken out and the radius increased from a little over an inch to 3½ in. by boring out in a nearby machine shop. The runner band C was then chipped to templet to a new curve and a reënforcing steel bank shrunk on the runner band.

Next at the portion of runner vane marked D the vane was chipped away both to get more clearance under the gate edges and to correct the vane angle for the new head condition. Third, at the runner discharge, at the region marked E, the vanes were cut back nearly three inches to remove vane portions claimed to be uselessly parallel, the engineer insisting that this cutting back would increase the power 20 per cent.

After all of these changes were completed, the turbine was put back into service. The output was actually increased 23 per cent over the first test and current meter tests indicated a gain of about 6 per cent in efficiency at the new peak of the efficiency curve. Even if there was no gain in efficiency, the power company was well pleased with the gain in power alone and the new maximum output, only 5 per cent below the original contract

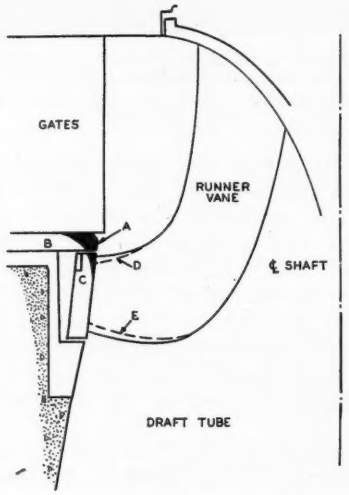


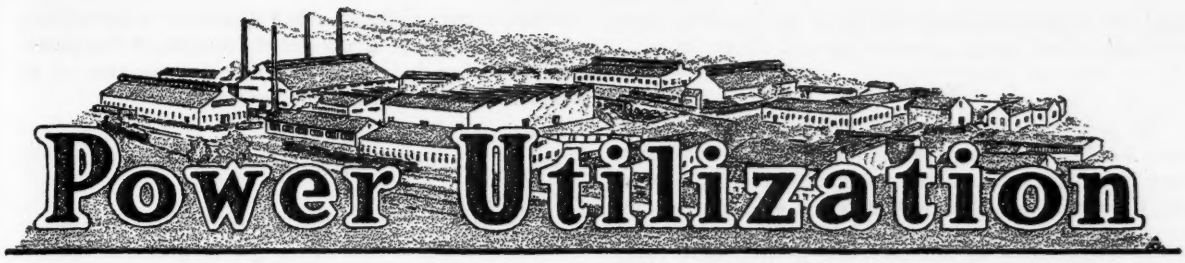
FIG. 2. SECTION OF TURBINE SHOWING CHANGES THAT WERE MADE

power, was taken as showing an improvement in design.

It is only fair to say that the original builder quit the turbine business some time ago, having gone into bankruptcy.

NEW ORDERS for 516 steel boilers were placed in February 1931 according to a report submitted to the Bureau of Census by 74 manufacturers comprising most of the leading establishment in the industry, as compared with 598 boilers in January, 1931, and 873 boilers in February, 1930.

Distribution of the boilers ordered in February, 1931, is as follows: 495 of these boilers were stationary boilers with a total heating surface of 526,947 sq. ft.; of this number 56 were water-tube boilers with a surface of 281,202 sq. ft.; 36 were horizontal return tubular, surface 40,311 sq. ft.; 60 vertical fire tube boilers, surface 17,163 sq. ft.; steel heating boilers, 276 boilers, surface 127,367 sq. ft.; locomotive, not railway, 2 boilers, 886 sq. ft.; oil country, 42 units, 46,691 sq. ft.; self-contained portable boilers, 20 units, 11,829 sq. ft.; miscellaneous, 3 units, 1,498 sq. ft. The remaining 21 boilers of the total were for marine service with a total heating surface of 95,396 sq. ft. Of this number, 11 were water tube boilers with a surface of 92,421 sq. ft., 4 were Scotch boilers, with a surface of 745 sq. ft. and 6 were miscellaneous with a surface of 2230 sq. ft.



Calculating the Strength of Gear Teeth

LEWIS FORMULA MOST COMMONLY USED BUT IT DOES NOT CONSIDER OPERATING OR LUBRICATING CONDITIONS. HOLLOWAY FORMULA TAKES THESE INTO ACCOUNT

MANY DIFFERENT FORMULAS have been proposed for calculating the strength of gear teeth. In general, these formulas can be divided into three classes: first, those that consider primarily the bending stress in the teeth; second, those that consider primarily the compressive strength of the teeth; third, those that consider the modern tooth sufficiently strong and consider primarily the wear and operating factor.

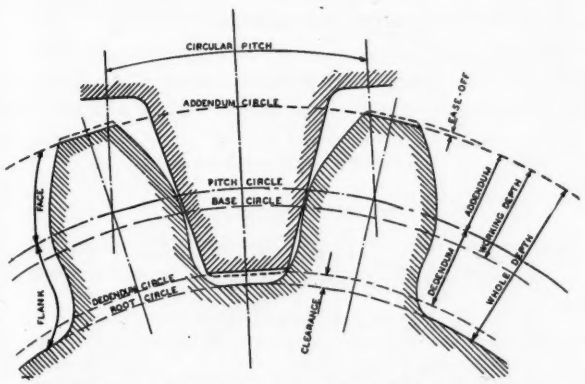


FIG. 1. NAMES OF PARTS OF GEAR TEETH

Elements of gear teeth and the common terminology are given in Fig. 1.

Taken together, the addendum and dedendum make up the tooth and the groove between two teeth is known as the space. In cut teeth the space and tooth thickness are equal at the pitch line. The distance from the center of one tooth to the center of the next, measured at the pitch circle is known as the linear or circular pitch.

One term sometimes used but not easily illustrated is the diametral pitch or the number of teeth per inch diameter of pitch circle. If a gear of six diametral pitch has 12 teeth its pitch diameter equals 12/6 or 2 in. Circular pitch is 3.1416 divided by the diametral pitch.

TOOTH FORMS

To meet various conditions, three forms of teeth are used as shown in Fig. 2, long, standard and stub. The long tooth has more metal at the base and greater inclination of surfaces to the radius. This gives greater strength at the root of the tooth but also greater leverage for the force between teeth and greater component of that force, tending to create friction in the bearings. The standard 14½-deg. tooth gives smooth operation, and small bearing friction but for a small number of teeth results in undercutting at the dedendum circle, hence weakness at that point. The 20-deg. stub tooth overcomes this weakness and has more rolling action between teeth with less sliding between tooth surfaces than the standard. The wearing surface is, however, reduced which may shorten the life of the gear under severe service.

Actual shapes of teeth of the two types can best be seen from Fig. 3 showing approximate methods of laying out teeth on a drawing board. For the involute tooth the outline of the working part is a single curve as indicated while with the epicycloid tooth, the curve of the tooth changes at the pitch circle. In all gears the curve outside the pitch circle is convex but the curve on the inside varies, being sometimes convex, sometimes radial and sometimes concave. The concave flank as generated by a circle rolling on the inside of the base circle is the most common. The epicycloid teeth have been largely superseded by the involute. Cycloidal teeth giving less pointed teeth than the involute were formerly widely used for cast teeth.

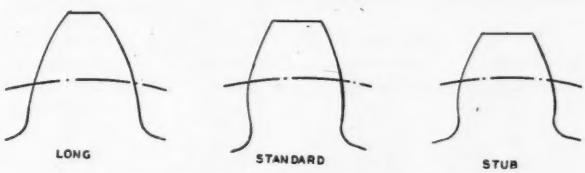


FIG. 2. THREE COMMON FORMS OF GEAR TEETH

It is a fundamental law of gear tooth action that the common normal of two tooth outlines at their point of contact must go through the pitch point or the point of contact of the pitch circles. Inasmuch as the normal of the involute curve is at all points tangent to the base circle, the acute angle between this line and a line tangent to both pitch circles is known as the pressure angle.

The smaller this angle the closer the base circle approaches the pitch circle and the less tendency for the gears to push apart, but there is the disadvantage of a wide tooth tip and narrow base, which tends to weaken the tooth. For many years a 14½-deg. angle was considered standard but of recent years this angle has been increased up to, and even in excess of, 20 deg. in order

to utilize a more favorable section of the involute curve and have a tooth with a narrow tip and strong base.

Efficiency

In practice, efficiencies will vary widely depending upon local conditions. For similar conditions tooth surface is probably the most important factor. Tests at the University of Illinois showed the efficiency of unhardened spur gears to be as high as 99 per cent and to be independent of the quantity of lubricant (provided sufficient was used to prevent heating and cutting); of the pitch line speed (within the limits of 60 to 1500 ft. per min.); of the obliquity of action, and of the load transmitted. Allen also reported efficiencies of 99 per cent in an A.S.M.E. paper.

From tests made a number of years ago, Lewis deduced the following: Tooth friction loss for 20-deg. stub teeth with the addendum about 0.24 of the circular pitch is less than 1 per cent; for 22½-deg. teeth with the addendum about 0.28 of the circular pitch about 1 per cent; for 14½-deg. teeth with the addendum about 0.32 of the circular pitch about 1.3 per cent; for spur 15-deg. teeth with long and short addendum over 2 per cent. Length of the addendum evidently has more effect than the pressure angle.

Strength Based on Bending Stress

Of bending stress formulas, the Lewis, proposed about 40 yr. ago, is the best known and most widely used. The Lewis formula may be written

$$L = f\,y\,s \div d \qquad (1)$$

or since

$$d\,c = \pi \qquad (2)$$

$$L = f\,y\,s\,c \div \pi \qquad (3)$$

where

- L = working load in pounds, (i.e. the component of the force tangential to the pitch circle)
- f = active working face in inches
- y = tooth form factor from Table I
- s = safe working stress in pounds per sq. in. (Eq. 4)
- d = diametral pitch
- c = circular pitch in inches
- π = 3.1416

TABLE I. VALUES OF TOOTH FORM FACTOR, Y, FOR LEWIS FORMULA

No. of Teeth	B&S full depth 14½ deg.	Full depth involute 20 deg.	Stub involute 20 deg.
12	0.210	0.245	0.311
14	0.226	0.276	0.339
16	0.242	0.295	0.361
18	0.261	0.308	0.377
20	0.283	0.320	0.393
25	0.305	0.339	0.418
30	0.320	0.358	0.437
43	0.346	0.396	0.464
60	0.358	0.421	0.484
100	0.371	0.446	0.506
150	0.377	0.459	0.518
Rack	0.390	0.484	0.550

Values of the tooth form factor, y, for spur gears are given in Table I. Figures in the last column also apply to Nuttall, A.G.M. and Fellows (4 and 8 pitch) stub teeth. For Fellows 5, 6 and 7 pitch use values slightly greater, for 9, 10 and 12 pitch use values slightly less than shown in the last column.

Safe working stress, s, is a function of the velocity of the teeth and of the material from which the gear is made. It can be calculated from an adaption of the Barth formula which may be written

$$s = S\left(\frac{a}{b + v}\right) + e \qquad (4)$$

where

- s = safe working stress to use in Eq. 1 and 3
- S = allowable static stress (Elastic limit divided by the factor of safety for material used)
- v = pitch line velocity in feet per minute
- a, b and e = constants depending upon the kind of gear (see Table II)

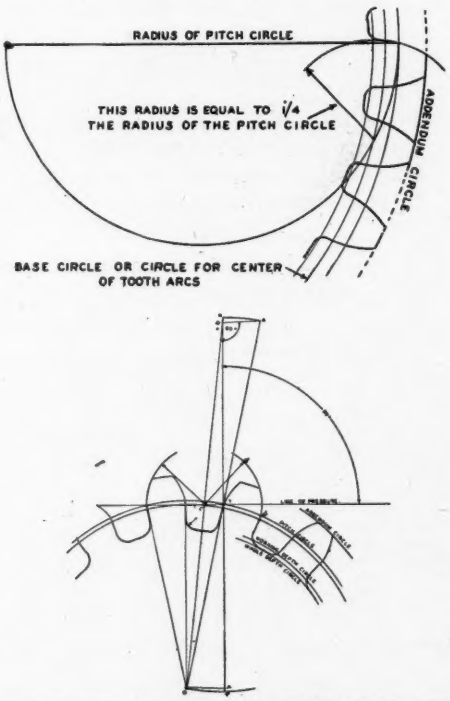

RADIUS OF PITCH CIRCLE
THIS RADIUS IS EQUAL TO ¼ THE RADIUS OF THE PITCH CIRCLE
ADDENDUM CIRCLE
BASE CIRCLE OR CIRCLE FOR CENTER OF TOOTH ARCS

FIG. 3. APPROXIMATE METHODS FOR LAYING OUT GEAR TOOTH FORMS; UPPER, SINGLE CURVE OR INVOLUTE; LOWER, TWO CURVE OR EPICYCLOIDAL

From experimental data values of S, a, b and e have been determined and are tabulated in Table II for different types of gears and different gear materials. It must be remembered that modifications of Eq. 1 and 4 are used by different manufacturers to give working results comparable with those they find in actual practice so that if more than approximate results are re-

TABLE II. VALUES OF CONSTANTS TO USE IN EQ. 4

Kind of Gear	S	a	b	e
Ordinary metal gears.....	....	600	600	0
Cut or ground gears.....	....	1200	1200	0
Phenolic or rawhide.....	....	150	200	0.25
Material				
Phenolic or rawhide.....	6000			
Cast iron	8000			
Bronze 12,000				
Cast steel 18,000				
Cast steel, heat treated.....28,000				
Forged steel 20,000				
Forged steel heat treated.....25,000 to 35,000				

quired, values should be taken from the catalog of the manufacturer in question.

Torque and Power

Having determined the working load or tangential force, L, the torque can be calculated from the equation

$$T = L\,r \div 12 \qquad (5)$$

where

T = torque in foot pounds
r = radius of pitch circle in inches

Horsepower transmitted can then be expressed as

$$hp. = 2\,\pi\,N\,T \div 33{,}000 \qquad (6)$$

or substituting Eq. 5 in Eq. 6

$$hp. = 2\,\pi\,N\,L\,r \div (33{,}000 \times 12) \qquad (7)$$

but

$$v = 2\,\pi\,N\,r \div 12 \qquad (8)$$

so that substituting Eq. 8 in Eq. 7

$$hp. = Lv \div 33{,}000 \qquad (9)$$

where

hp. = horsepower
N = r.p.m.
v = velocity of pitch circle in feet per minute

For practical purposes it may be convenient to calculate the horsepower direct without going through the intermediate steps. Equation 1 can be substituted in Eq. 9 to give

$$hp. = f\,y\,s\,v \div 33{,}000\,d \qquad (10)$$

Compressive Strength

Example of a formula, based on the compressive strength of the tooth, is the Italian, Pomini formula

TABLE III. CONSTANTS TO USE IN EQ. 11

Number of Teeth in Pinion	Reduction Ratio 1:1	1:2	1:3	1:4	1:5	1:6	1:8	1:10
12	2.8	3.4	3.8	4.2	4.36	4.54	4.8	5.0
14	3.2	3.8	4.2	4.6	4.88	5.08	5.4	5.6
16	3.5	4.2	4.64	5.06	5.36	5.58	5.84	6.1
18	3.8	4.4	5.0	5.4	5.76	5.96	6.24	6.44
20	4.2	4.9	5.4	5.9	6.2	6.4	6.88	6.9
24	5.0	5.76	6.3	6.8	7.04	7.3	7.6	7.8
28	5.7	6.4	7.04	7.6	7.88	8.14	8.5	8.64
32	6.4	7.28	7.92	8.4	8.8	9.04	9.4	....
36	7.2	8.1	8.76	9.24	9.6	9.88	....	....
40	7.9	8.84	9.56	10.28	10.44	....	....	....

$$L = f\,R\,c\,\frac{1480}{v + 32.8} \qquad (11)$$

where

L = working load in pounds
f = active working face in inches
R = gear factor (given in Table III for enclosed lubricating gearing)
c = circular pitch in inches
v = velocity in feet per second

In this equation, L can be used direct for cast-iron spur gears but for steel spur gears it can be multiplied by 3. As before, Eq. 11 can be substituted in Eq. 9 to give

$$hp. = f\,R\,C\,v\left(\frac{1480}{v + 32.8}\right) \div 33{,}000 \qquad (12)$$

TABLE IV. INSTALLATION FACTOR B OF EQ. 13

Types of Installation	Tooth Velocity in Ft. per Min. 1000 to 2000	500 to 1000	Under 500
Enclosed Units.....	1.0	1.2	1.4
Open Gears	0.8	1.0	1.2

TABLE V. LOAD FACTOR C OF EQ. 13

Character of Loads	Conditions of Service: Continuous 24 hr. day	Continuous 10 hr. day	Intermit. over 5 hr. day	Intermit. under5 hr. day
Full load rating with shutdowns only for repairs..	0.45	0.60	0 .80	1.10
Friction loads to full motor over-loads with frequent power fluctuations	0.60	0.80	1.10	1.50
Friction loads to part full load rating, average running ¾ full load rating..	0.80	1.10	1.50	2.00
Friction loads to part of full load rating, with greater service under ½ full load rating	1.10	1.50	2.00	2.70

TABLE VI. MATERIAL FACTOR M OF EQ. 13

Pinion	Wheel	M
1P	1W	1.0
2P	1W	1.1
3P	1W	1.2
4P	1W	1.3
5P	2W	1.4
6P	2W	1.5
7P	2W	1.6
8P	3W	2.0

TABLE VII. MATERIAL SPECIFICATIONS FOR PINIONS AND WHEELS LISTED IN TABLE VI

Number	Material	Brinell
1P	.40 to .50 Carbon	175 to 200
2P	.50 to .60 Carbon	175 to 200
3P	.50 to .60 Carbon	200 to 225
4P	.50 to .60 Carbon	225 to 250
5P	SAE No. 3240 or Equiv.	225 to 250
6P	SAE No. 3240 or Equiv.	250 to 275
7P	SAE No. 3240 or Equiv.	276 to 300
8P	SAE No. 2320 Case Hd.	450 to 500
1W	Approx. 0.30 Carbon	
2W	Approx. 0.40 Carbon	
3W	Special	

Calculating Strength from Service Factors

It is apparent that the formulas given above (i.e. Eq. 1, 10, 11, 12) are not entirely satisfactory for modern use because they do not bring into consideration the operating or lubricating conditions except indirectly as the constants may be varied by experience. Obviously, it is not correct to design a pair of gears to drive a conveyor with a starting overload of about 100 per cent and a running load of only 60 per cent with the same formula used to design a pair of rolling-mill gears where heavy continuous overload and service are expected.

The formula below (received by private communication*) is based on a wear factor and considers installation conditions, load and gear materials. In this equation

$$hp. = fd^2\,N\,B\,C\,M \div 1260 \qquad (13)$$

where

hp. = horsepower
f = active face width in inches
d = diametrical pitch in inches
N = r.p.m.
B = installation factor (Table IV)
C = load factor (Table V)
M = material factor (Table VI)

*From T. Holloway of the Farrel-Birmingham Co., Buffalo, N. Y.

Constants for the solution of this question are given in Tables IV, V and VI. Physical properties of the pinion and wheel materials, 1P, 2P, etc., of Table VI are given in Table VII. Solution of this equation is comparatively easy as it involves only straight multiplication and division.

Theoretically, there is no reason to believe that herringbone gears should transmit more power than straight tooth gears. Practically, however, the higher degree of accuracy with which they are cut reduces shock and vibration which tend to fatigue the metal.

That this is true is easily seen from the adaptations the fundamental formula made to apply to certain gears. This point is illustrated by Table II. None of the formulas given above directly involve an accuracy factor, however, although this accuracy is considered when calculating constants for different types of gears. Eq. 13 as it stands was developed primarily for very accurate continuous herringbone gears. For commercial gears this means a total inaccuracy of division and tooth contour of not over 0.002 in. for gears from 20 in. to 20 ft. in diameter; not over 0.001 in. for gears from 10 to of 20 in. in diameter and not over 0.005 in. for gears under 10 in. diameter.

Steam and Air Distribution in a Sugar Mill

By Dan Gutleben

STEAM is distributed in conventional asbestos-protected piping, mostly welded or joined with rolled steel Van Stone flanges. It is used in the power plant and for the boiler house auxiliaries. In the refinery, a quantity of direct-acting steam pumps are in use, where regulated speed is desired through float control. They are also used for pumping heavy syrup and have the advantage that they will not exert themselves beyond their structural strength. Steam and exhaust piping is arranged vertically through the buildings, which allows convenient connections by welding on each floor where service is required.

A large element in the cost of steam distribution is the removal of the condensate and the flash steam from traps and heated tanks. For 12-lb. low-pressure steam U-traps are used, especially for the drainage of exhaust steam lines which contain oil that has a tendency to clog traps. The flash from all traps as well as vents from heating surfaces and hot wells is collected in a 14-in. vertical line that starts on the second floor of the 10-story char house and ends in a jet condenser just under the roof. This condenser receives daily about 1,000,000 gal. of warm water at 125 deg. F. from the evaporator and pan condensers. It condenses the vapors delivered by the 14-in. pipe and returns the water to a heater for heating to 210 deg. The saving thus credited to the steam distribution system is considerable.

Compressed Air Distribution

Compressed air is used for pneumatic tools and sundry process purposes. It is also used for stirring liquids for which purpose it is not so economical as are mechanical stirrers, hence it is used only where it is inconvenient or impossible to apply a mechanical device.

In the compressed air system are three sets of compressors complete with receivers, giving pressures respectively 20 lb. for pressing the liquor off the char filters, 70 to 100 lb. for supplying the mechanical filters and By-Products plant and 115 lb. for operating pneumatic tools and general construction purposes. Two of the receivers are 78 in. by 18 ft. One of these is served by an 18 by 18-in. single-cylinder, steam-driven compressor, which runs continuously, though at slower speed

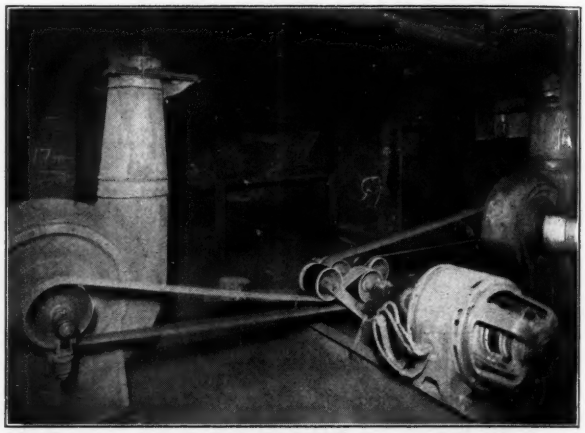


FIG. 1. ONE MOTOR DRIVES TWO BLOWERS

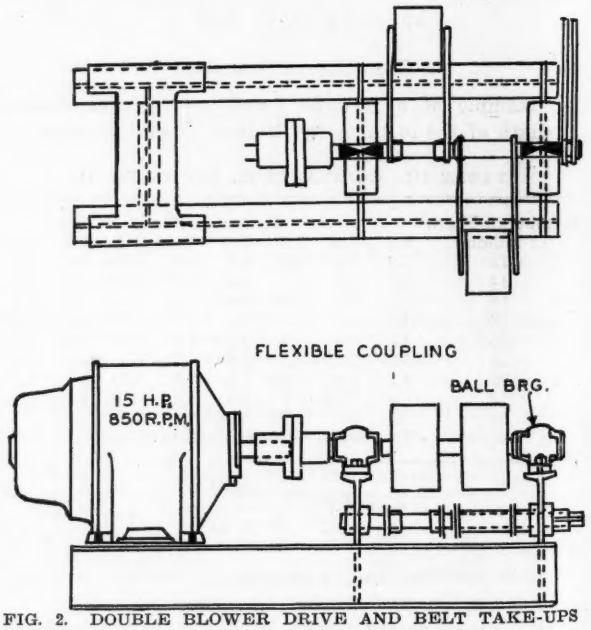


FIG. 2. DOUBLE BLOWER DRIVE AND BELT TAKE-UPS

when its receiver pressure reaches 115 lb. This receiver overflows via a relief valve into the second receiver which is served by an 11 by 12-in., single, electric-driven compressor, controlled to start at 70 lb. and stop at 100 lb. and running 200 r.p.m. Most of this air is used at the Vallez filters where reducing valves are provided, set at 45 lb.

Receivers are installed in the cellar and distribution is effected through risers located at convenient places and having hose connections on each floor. The electric-driven compressors are connected with short-center belts

or Texropes according to age, the latter being the newer and preferred arrangement. Air filters are provided for the suction and coolers for the discharge of compressors. For drying drums in the By-Products plant, the air is reheated. Compressed air was formerly used for ventilating tank cars as well as tanks to permit workmen to enter for cleaning or repairs but this is now done with rotary blowers, Figs. 5 and 6, which deliver their large volume of low-pressure air through canvas hose.

Pneumatic Presses

USE OF air-operated presses in the arts has increased production processes in many fields because, although air is compressible, it acts quicker than water and leaks of any kind do not interfere with the operation. For small equipment its application, therefore, is particularly useful hence we find it utilized in connection with platen presses of many kinds such as are used in the manufacture of non-shattering glass, hard-rubber articles and other products pressed from plastic materials.

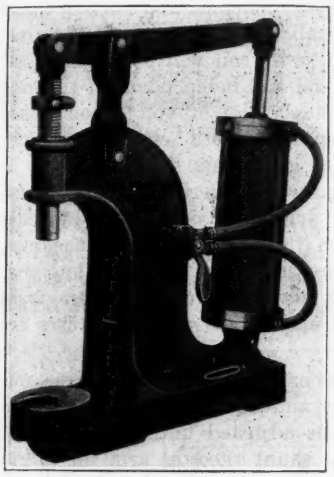


FIG. 1. AIR-OPERATED ARBOR PRESS

FIG. 2. AIR RIVETER FOR 125-T. PRESSURE HAVING AN 18-IN. GAP AND 75-IN. REACH

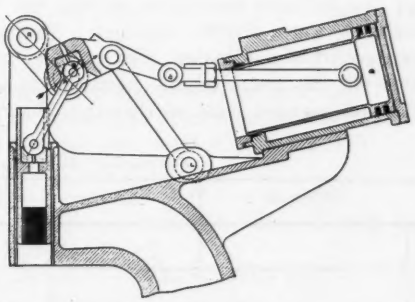


FIG. 3. AIR RIVETER MECHANISM

Air-operated arbor presses such as shown in Fig. 1 are on the market. With air at 80 lb. pressure as high as 6800 and 12,000 lb. pressure may be exerted by different sizes of such presses, consuming 1.47 and 2.60 cu. ft. of air respectively.

Air riveters of the kind shown in Fig. 2 are essentially presses since only one stroke is required of the piston to drive a rivet. The action of this riveter is indicated in Fig. 3 which shows it in its open position. The mechanism causes the closing action to be fast at first due to the toggle action and maximum pressure is attained at half stroke. This is followed by a slower action under simple lever motion, giving a predetermined pressure on the die to the last portion of die travel.

Air is used also in combination with water and steam presses in equipment which has been introduced recently, functioning in an accumulator or intensifier attached to the press.

Ground Wires

REGARDING the question of grounding brought up by Mr. Peterson, the writer feels that ground wires should be carefully fastened to a water pipe only in case no suitable or better ground is available.

Some telephone concerns teach their employes that a water pipe will make no reliable ground wire connection for the reason that some workmen use a lot of paint or other dope on pipe threads, so that a ground wire is to be attached to such pipes only where no reliable ground rod is available.

So long as a water pipe is full of water, it will give a good ground, if the ground wire is soldered to the pipe. When a wire is just rolled tight around a black cold water pipe in a warm room, rust from air condensation soon forms on the outer surface of the pipe and destroys the efficiency of the rolled wire connection. Even when a wire is soldered to a black or galvanized iron pipe, the ground will be poor, if the pipe is emptied of water for any reason and the pipe threads are coated with an insulating paint or dope, such as dissolved phonograph records or shellac. When a ground wire is connected to a water pipe a long distance from where the pipe enters the earth and there are a considerable number of pipe joints between the two points, an inefficient ground is quite possible.

On all high current wires, the wire should be attached to the pipe with a proper clamp and, as an extra precaution, the clamp should also be soldered to the pipe.

A ground wire should never be connected to a gas pipe.

Toronto, Can. JAMES E. NOBLE.

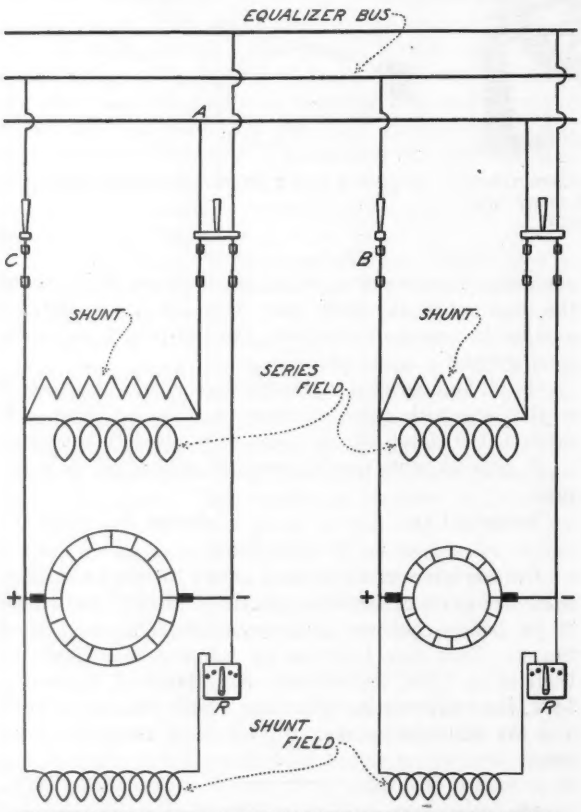
STOKER HISTORY dates back about 100 yr. to the circular fire grate of Brunton, patented in 1819, or almost 20 yr. before coal was used commercially in the United States. This was followed by the traveling grate of Bodmer in 1834, the endless chain grate of Juckes in 1841, the reciprocating grate bar stoker of Hall in 1845 and the underfeed stoker of Vickers at about the same date.

MEASURED by volume, air is 76.85 per cent nitrogen.

Parallel Generators Need Equalizer

DIRECT CURRENT for lighting a manufacturing plant was supplied by a 60-kw. compound-wound generator driven by a high-speed steam engine, until gradual expansion of the plant overloaded the generator some 30 per cent at peak demand. To relieve the stress another machine was purchased, to run in parallel with No. 1 during peak load, the addition being a 40-kw. unit driven by a Diesel engine.

Making the new installation himself, the engineer neglected to provide an equalizer between the generators and the mistake was quite evident the first time the machines were thrown together. Engine speeds had been accurately adjusted, also voltages but, when load came on, the steam engine persisted in running ahead of its oil-burning mate so that the 60-kw. unit took all the load and even tried to drag its team-mate up to speed.



CONNECTIONS FOR GENERATORS RUN IN PARALLEL

What happened was that the speedier machine increased its voltage hence the current through its series field, at the same time sending reverse current through the series field of the slower machine and cutting down its voltage. With an equalizer bus as shown in the illustration, current in each series coil will be proportional to the resistance of the coil and independent of the load division between machines. Rise of voltage on either generator builds up current in both series coils, hence increases voltage of both generators. The equalizer is connected between armature and series coils, thus putting the series coils in parallel. As two-pole switches were already in use on the mains of both machines, single-pole switches were used for equalizer bus connection but these must always be closed *before* main switches are closed and opened *after* main switches are opened.

To get proper division of load, No. 1 machine was loaded to rated capacity and its series coil shunt of insulated metal ribbon was adjusted until the voltmeter showed 115 v. with the shunt rheostat arm set to cut out about half the rheostat resistance. In like manner No. 2 machine was adjusted at full load. Test of the resistance of main leads from generators to switchboard showed that the resistance of No. 2 leads was greater than of No. 1. So there would still be a tendency to uneven division of load yet further adjustment of series coil shunts would do no good since the equalizer puts both series coils and shunts in parallel.

As it was impracticable to increase the length of No. 1 leads, the expedient was tried of slipping a pair of iron washers beneath the lug at A, connecting No. 1 positive lead to the positive bus. It was not quite enough but a third washer did the trick so that the generators paralleled and divided the load perfectly.

St. Louis, Mo. A. J. DIXON.

Specific Heat of Diphenyl

ENGINEERS are learning more and more about the remarkable chemical substance called "diphenyl." Diphenyl is already being used in engineering in connection with heat transfer work. Chemists tell us that it is an ideal substance for reheating steam back to full initial temperature. Just few years ago, it was regarded mostly as a curiosity. Its price was then too high for

use in practice. Now, however, we are told that it can be bought by the carload at 30c a pound.

On account of the increasing importance of diphenyl considerable research work has been performed on it, particularly in the research laboratory of applied chemistry at the Massachusetts Institute of Technology. Recently a report was published concerning diphenyl by H. O. Forrest, E. W. Brugmann and L. W. T. Cummings, in the official organ of the American Chemical Society. In this report, they showed tables of the specific heat of diphenyl at various temperatures; but they did not develop a formula or rule for use in computations, so I decided to try my hand at it. I developed the following approximate formula:

$$0.001t + 0.32 = \text{Specific Heat}$$

where t = temperature of diphenyl in degrees Centigrade.

This formula applies to all temperatures from 80 deg. to 360 deg. C.

My formula was then submitted to the original authors named above who in turn suggest the following as being "probably better" than mine:

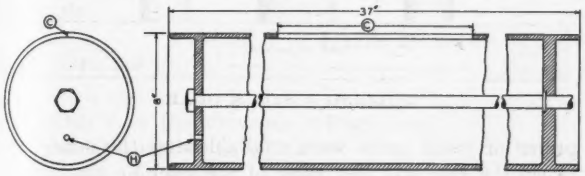
$$0.0012\ t + 0.300 = \text{Specific Heat.}$$

The writer hopes that the foregoing will prove to be of value to present and future users of diphenyl as well as to its manufacturers.

Newark, N. J. W. F. SCHAPHORST.

Peculiar Bursting of Pump Plunger

DURING THE summer months, our 14 and 8 by 12-in. duplex outside center-packed boiler-feed pump, which operates normally at 150-lb. pressure, was shut down.



BURSTING OF PUMP PLUNGER AVOIDED BY RELIEF HOLE

When it was started in the fall, one of the plungers suddenly began to leak badly. Examination disclosed a crack lengthwise of the plunger near the middle portion and about 14 in. long as shown at C in the sketch.

When preparing the plunger for welding, the writer noted that it was practically full of water. The only explanation we could find for the failure was that due to porosity of the casting or, perhaps, to a leak around one of the piston rod fits, the filling of the plunger being due to vacuum formation when the pump ceased operating on hot water in the spring. Probably the leak had rusted shut during the summer and when it was started in the fall on hot water, the water inside of the hollow plunger expanded, building up a pressure sufficient to crack it.

Calculations indicate that this pressure must have been in excess of 1000 lb. per sq. in. We drilled a ⅜-in. hole in one end of both plungers, as shown at H, so as to provide an opportunity for pressure release should this condition ever occur again.

Flint, Mich. J. W. RUPERT.

CO_2 Recorders for Natural Gas Combustion

SOME TIME AGO our company added carbon dioxide recorders to the combustion equipment of the boiler house here, and I am offering the following brief notes on the utility of these instruments when serving gas fired boilers. A complete analysis of the flue gas is desirable for certain purposes in all plants but for regular boiler operations, if the percentage of CO_2 is known, simple calculations, tables or charts will afford the boiler operator the information needed to hold the combustion efficiency at a high point.

If readings of recorders are to be interpreted correctly, one of the first factors that should be determined is the maximum CO_2 for the fuel burned. The fuel burned in this instance is natural gas, the composition of which, as given by combustion analysis, runs about 80.5 per cent CH_4; 18.2 per cent C_2H_6 and 1.3 per cent N_2. The calculated maximum CO_2 is 12.1 per cent. The maximum CO_2 factor, when so found, may be checked by Orsat tests, care being taken in securing a determination to avoid a sample showing carbon monoxide as the presence of this gas usually indicates unburned fuel other than CO. An analysis showing 9.1 per cent CO_2 and 5.2 per cent O_2, or any percentages of these gases in the proper proportions will answer. Substituting these values in equation 1 or 2 and solving, the maximum CO_2 will be found to be 12.1 per cent as calculated.

(1) Ultimate CO_2 per cent $= D \div [1.00\ (A \div 20.93)]$
where D = percentage of CO_2 as analyzed
A = percentage of oxygen as analyzed

(2) Ultimate CO_2 per cent $= 20.93\ (D + M) \div (20.93 - A) + 0.4\ M$
where M = percentage of CO as analyzed

The oxygen percentage from the Orsat analysis may be checked by equation 3 or 4

(3) Oxygen, per cent $= 20.93 - 20.93\ D \div U$
where U = ultimate CO_2, per cent

(4) Oxygen, per cent $= 20.93 + 0.4\ M$
$= 20.93\ (D + M) \div U$

Since the maximum CO_2 for this gas is a constant, the following equations may be written

(A) Oxygen, per cent $= (12.1 - D)\ 1.73$

(B) CO_2, per cent $= (20.93 - A) \div 1.73$

(C) Volume of products of combustion, cu. ft., dry $= V = 9.67 \times 12.1 \div D = 117.07 \div D$

(D) Excess air, per cent $= (V - 9.67) \div 9.67$

While the fuel burned in this instance is generally uniform in quality, changes occur, at times, in its calorific value. The variations in the maximum CO_2 have ranged, under extreme conditions, from 11.7 to 12.3 per cent, representing changes in the heat content of the gas of from 1020 to 1230 B.t.u. per cu. ft. These values agree quite closely with readings taken from the fuel calorimeter. Under normal operating conditions, however, the maximum CO_2, as checked by the daily Orsat test, runs close to 12.1 per cent, giving a uniform standard by which to judge the efficiency of the combustion from the CO_2 percentages.

By far the greatest loss in the boiler house is due to the heat carried up the stack. The principal factors contributing to this loss are high exit gas temperatures

and excess air. These factors are interrelated and are controllable within certain limits. For each 10 per cent reduction in the excess air we may expect an increase of about 200 deg. F. in the furnace temperature and as high furnace temperature means better combustion, a more efficient heat transfer and lower stack temperature, it is obvious that the temperature of the furnace should be kept at a high point, the limiting factor being the refractories used with this fuel. Or, viewed from another angle, the excess air should be kept at the lowest point at which the fuel may be completely burned, which is about 20 per cent.

If sufficient air is supplied, the combustion of a cubic foot of this gas produces 1.17 cu. ft. of CO_2. This 1.17 cu. ft. of CO_2 becomes a constant, the variables being the quantities of oxygen and nitrogen present. Hence the CO_2 per cent as shown by the CO_2 recorder, serves as an index of the quantity of excess air present, which is its chief function.

If we substitute in equation C the value for CO_2, 9.10 per cent, obtained from the Orsat analysis mentioned above and solve equation D, the excess air as calculated becomes 33 per cent. It will be noted that this is above the conventional 20 per cent excess air limit for natural gas fuel. Under normal operating conditions, however, the excess air percentage used is less than the limit mentioned.

Recorders set up strong incentives to maintain good firing and proper maintenance methods. They are of direct help to the fireman in several ways. As a rule steam pressure change follows the CO_2 change, the boiler operator usually getting his first intimation that there is something wrong with the fires from a drop shown on the recorder. He then inspects the furnaces for indications of incomplete combustion, examines the gas pressure, pyrometers, thermometers, draft, dampers and the like and quite often may restore operation to normal before the steam pressure, which is the usual indicator of disturbed firing conditions, has been affected materially.

Finally CO_2 recorders have added a new feature to the boiler house daily report as plant executives now know not only how much fuel is consumed during each shift, its calorific value, etc., but how much fuel was burned that went to waste. Equations 1 and 3 are from Combustion, 2nd Edition, American Gas Association; Nos. 2 and 4 from Power Plant Engineering, July 1, 1930.

Sugar Grove, Ohio. HENRY COONEY.

Fire Risk with Oil Pipes

WHILE RUNNING loaded, a 5000-kw. turbine developed a leak in one of the lubricating oil pipes where the pipe entered a flange. The pipe blew off the flange before any steps could be taken to stop the leak, the oil spurted on to an adjacent steam pipe carrying steam at a temperature of 650 deg. F. Owing to the high temperature of the steam pipe, the oil immediately ignited and a conflagration started.

As the oil pressure on the turbine lubricating system dropped, the automatic steam pump started up and continued to pump oil on the fire. Some nearby woodwork and the power house roof were severely burned; surface damage only was done to the turbine, as the machine was quickly stopped and the fire extinguished.

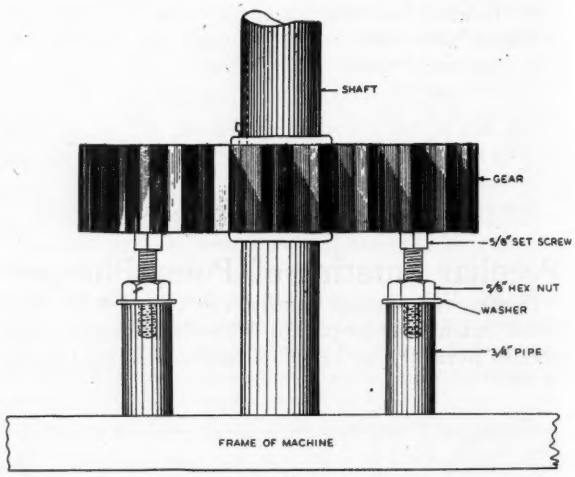
As it is found that lubricating oils will ignite at a temperature above 626 deg. F., where oil pipes are run adjacent to high temperature steam mains they should be screened from one another so that oil cannot spray on the pipe.

Both on account of the fire risk due to spraying or dripping oil, and the financial loss due to oil wastage, lubricating pipe joints should be securely made. At the same time oil pipes should be securely braced to prevent vibration, as vibration is a frequent cause of leaking oil joints.

Hertz, England. W. E. WARNER.

Gear Removal Difficulty

SOME TIME AGO the writer saw a difficult job conquered where proper tools were unavailable. It was necessary to remove from a machine a gear which was tight on the shaft as well as rusted in place. No gear



PULLING A STUCK GEAR

puller or small jacks were available and the space between the gear and the frame of the machine was rather limited.

Finally were dug up two ⅝-in. set screws with nuts to fit as well as two washers. Then two pieces of ¾-in. pipe were cut and these items placed between the gear and the frame of the machine as shown in the sketch. When pressure was applied to the two nuts alternately, it seemed as if they would fail to move the gear but eventually it broke loose. When the gear was moved as far as the screws would allow, two more pieces of pipe were cut a trifle longer than the first ones and pressure again applied. In a short time, the gear was off and the job complete. Hammering or prying with bars would have done no good in trying to remove this tight gear but these two simple makeshift jacks did the work quickly, simply and efficiently.

Cold Spring, Minn. CHAS. A. PETERSON.

IF A FUSE, THE electrical safety valve, blows out you are overloading your wiring system or using a defective device. The trouble is not corrected by inserting a larger fuse. A fuse of the proper size is your protection against fires or accidents. Have the fault located and corrected.

Calculating Size of Conductor for Short A. C. Line

WHAT SIZE conductor should be used in an underground feeder, 200 ft. long to transmit a load of 110 kw., at 440 v., 3 phase? The load is inductive, consisting of 3 phase motors and lights. The power factor is 0.85 and the allowable voltage drop, 4 volts. C.J.K.

A. The length of this line is such that the ordinary effects of inductive reactance can be neglected and to determine the current, the following formula should be used:

$$I = \frac{\text{kw.} \times 1000}{E \times \text{P.F.} \times 1.73} = \frac{\text{kw.} \times 580}{E \times \text{P.F.}}$$

in which I = the current in amperes.
E = the voltage of the circuit.
P.F. = the power factor.

Substituting proper values in this formula, we have:

$$\frac{110 \times 580}{440 \times 0.85} = \frac{63{,}800}{374} = 170.5 \text{ amp.}$$

The size of wire to carry this current is given by the formula:

$$\text{Circ. mil} = \frac{19 \times I \times \text{length in feet}}{V}$$

in which V = the allowable voltage drop.

Substituting, we have:

$$\frac{19 \times 170.5 \times 200}{4} = 161{,}975 \text{ circ. mil}$$

From a table of wire sizes, we find that No. 3/0 conductor has a cross section of 167,800 circ. mil, well on the safe side, so this is the proper size conductor for this circuit.

Compressed Steam for House Heating

WE ARE making studies in regard to the practicability of compressing low-pressure steam for high-pressure uses, where a high-pressure supply is not available, and of house heating by a reversal of the refrigeration cycle. In this regard, we desire to obtain any available information on either subject. Would it be possible for you to refer us to any such articles which may have appeared in your magazine from time to time? Any information you may be able to supply us will be appreciated. L. A. L.

A. Two stations in Detroit are now working on this basis, buying steam from the Detroit Edison Co. and compressing it by a motor-driven compressor for high-pressure work.

The process has been used in Detroit for steam laundries, steam being supplied to the customer at 35 lb. and 290 deg., being compressed to 75 lb., the temperature running between 410 and 490 deg. Steam consumptions of 200 up to 750 lb. per hour have been taken care of. The average consumption is around 450 lb. an hr. The compressor is 9½ in. diameter by 12 in. stroke, belt driven by 60-hp. d.c. motor, 1200 r.p.m., compressor running at 250 r.p.m. The steam receiver has three safety valves, one set at 80 lb. to discharge back into the supply tank. The others set at 100 lb., discharging to atmosphere. Receiver and piping are covered with 2 in. of 85 per cent magnesia. The compressor steam is superheated about 120 deg. Compressor maximum capacity is 1000 lb. an hr. and electrical energy required averages 40 kw-hr. for 1000 lb. of steam delivered.

Estimates on comparative cost of supplying compressed steam with the charge to the customer for low-pressure steam $1.00 per 1000 lb., give the cost for the compressed steam for a year at about $630 more than would be the cost from oil-fired boiler to deliver steam direct, but of course the nuisance of the steam plant is eliminated in the laundry.

The foregoing comparison of cost includes that for low-pressure steam used in the washing machines.

Corliss Engine Governor Rod Adjustment

HOW CAN YOU tell whether the governor rods of a Corliss engine are of the proper length? F. J. K.

A. Adjustment of a Corliss engine governor is accomplished by first blocking it so that the balls stand in the position they would assume at normal speed, as when the piston is in mid position, and fastening the reach-rod lever at right angles to a line midway between the reach-rods.

Now turn the engine to the point at which cutoff should occur, which is usually at about 1/5 stroke, and adjust the reach rod for that end so as to cause the valve to trip at that point. The valve and the reach rod for the other end of the cylinder must be adjusted in a like manner. Now, lower the governor to the lowest position and observe that the cutoff mechanism does not work but allows steam to be taken during the full stroke of the piston.

Definitions of Bag and Blister

WHAT IS the difference between a bag and a blister on a boiler shell or tube? R. B.

A. A bag, sometimes called a bulge, is a distortion of the entire thickness of the plate or tube where it takes place, while a blister is a lamination or separation of the plate due to foreign materials being imbedded in the ingot before the plate is rolled.

Editorial Comment

Weather Now Enters Specifications

For many years manufacturers have endeavored to try out new models and designs under working conditions, so that they may make no mistakes in recommending the proper types of equipment for the service to which the equipment is to be put. One of the first noteworthy steps along this line was the Holyoke hydraulic testing laboratory. Later manufacturers and users coöperated in testing electric circuit breakers and steam valves under working conditions, which could not be simulated in the manufacturers' laboratories. The value of these tests has convinced many manufacturers that laboratories to test out even their largest products are paying investments as is evidenced by the many fine industrial laboratories fully equipped with instruments and manned by scientists.

Many difficulties have been encountered in endeavoring to duplicate the conditions of actual service and it is only as other industries have developed that these problems have been solved. We are reminded of this fact by the recent announcement of an automobile engine manufacturer, Tillotson Manufacturing Co., that an air conditioning plant has been installed for the purpose of duplicating atmospheric temperature conditions, at any time of the year, which may be encountered by automobile engines in practical service.

It is conceivable that other conditions than temperature could be duplicated to advantage in a laboratory of this sort. Early users of Diesel engines met difficulties in operating their engines at high altitudes because of the low atmospheric pressure. This problem has been solved but a laboratory in which barometric pressure could be varied from that in the deepest mine to that at the highest altitudes reached by aeroplanes would have aided greatly in perfecting designs. And why not extend the conditioning to include variations in humidity, dust and gas conditions. Many failures of plant equipment are due to moisture conditions and acid fumes, conditions not insurmountable but frequently unforeseen by the purchaser and manufacturer.

In specifications of the future, manufacturers equipped with complete testing laboratories will suggest that not only load conditions be included but that the atmospheric conditions mentioned above be definitely described.

Should Speakers Be Seen But Not Heard?

That speakers at engineering conferences should be seen but not heard is a sentiment that has been growing in strength in the engineering field for some time. To speak frankly, the usual long program of three or four highly technical papers in the morning session, two or three at the afternoon session, each requiring from 30 to 45 min. to read and leaving little time for discussion, has bored engineers stiff. In short, if they could only have the speeches without the speakers, many engineers feel that they could really enjoy themselves at meetings.

It can be done. Two or three engineering bodies are now doing it. Furthermore, a new plan is to be tried that may prove to be more flexible and adaptable than any so far proposed.

At a meeting of the A.S.T.M. and the A.S.M.E. to be held at Chicago, in June, one of the features will be a joint symposium on the engineering problems involved in the use of metals at high temperature. It is divided loosely into two parts: a discussion of the engineering needs of the industries and another on the general subject of properties of the various alloys. About thirty papers are planned, with the understanding that no author is to present or even to summarize his own paper.

Instead, all the papers of each group will be summarized by a representative of one of the joint A.S.T.M. and A.S.M.E. committees. Neither representative will prepare a paper of his own; his function is to set forth a general picture of the situation as given in the detailed papers. The subject will then be opened for discussion, with the authors ready to answer questions that may be asked.

All the papers, of course, will be pre-printed and in the hands of members well in advance of the meeting because the principal object of the symposium is to bring out discussion of important points.

Here is a plan that seems to promise much in the way of enlivening a meeting. For years Power Plant Engineering and other agencies have added their voices to those of individual engineers, inveighing against the deadening boredom of many technical meetings caused by the multiplicity of technical papers bristling with graphs, calculations and statistics, the speaker who mumbles inaudibly into his MS for 45 min., and the speaker who devotes half of his paper to tracing the development of equipment from the amoeba. The net result of these and other irritants is a feeling that "after all, the principal value of engineering meetings is in the social contacts" and that "speakers should be seen but not heard."

It is perfectly true that social contact is the principal value of many meetings as usually conducted. But it should not be entirely true. There is a tremendous value to the engineer in the technical contact with his fellows as well as in the social contact. The former is the fundamental reason for engineering meetings but it has been too often subverted into an excuse for a golf tournament. It is to be hoped that a plan such as that outlined above will work out so successfully that it will make attendance at these meeting the stimulating mental adventure that it really should be.

Off Duty

It always has been our aim in this column to be quite frank about this business of going "Off Duty." We have not hesitated to propound its virtues and have even advocated a more general application of the idea: in the vernacular, we have made no bones about our deriving a certain amount of pleasure out of it. Yet there have been times when we have had misgivings about expressing ourselves so freely on this question for we realize that work always has been considered a virtue and any attitude to the contrary has had to be disguised in a most subtle manner. Being human, it is our inclination to be lazy but our training and upbringing, our fear of the rules of convention have restrained us in the expression of our honest convictions and so when we have expounded the virtues of "Off Duty" or leisure, we have implied that such Off Duty time must first be earned by *work*.

Work! What a word! Who invented it and attached to it the virtuous qualities it is supposed to possess? Who thought up all the moral aphorisms that bid us work and never play? Certainly no relative of ours. For we don't like work but until now we never have had the courage of our convictions to admit it publicly.

Well then, why all this burst of courage at this late day? Why this sudden inversion of policy, this unfeigned disregard for the rules of convention and decency; this flouting of public opinion? Why this remarkable stiffening of backbone?

The truth is, we have discovered a man after our own hearts, so to speak—a fellow mortal who thinks as we do but who with enviable courage comes forth boldly and asserts that this whole theory of work being a virtue is just so much rubbish. These are our sentiments exactly. It is in the language of the day a lot of hooey, hokum, and baloney—in other words, "the bunk." And this man, to whom no doubt some day a gold-plated monument will be erected, presents his ideas in no less respected medium than the current issue of "Harpers." "The god of work," says he, "must be cast down from his ancient throne, and the divinity of enjoyment put in his place. Work must be recognized not as a virtue but as an intrinsic evil. We must develop a new philosophy of idleness."

Now there is a man who deserves all the admiration at our command—a man whose undying fame will go down through the pages of future history in letters of gold. The man who abolished work! Three cheers and a couple of huzzahs!

For work has no place in this modern world of the machine and the sooner we recognize this, the better it will be for us. From time immemorial work has been glorified. Song and story have paid homage to its merits; it is the accepted formula for success and social esteem and has been described as the great cure for all the maladies and miseries that ever beset mankind. Expressed in the doctrine of Mr. Coolidge—Silent Cal, the columnist—"To provide for the economic well being of our inhabitants, only three attributes are necessary—honesty, industry and thrift." How simple!

The economic well being of our inhabitants—industry! Yet in this year of unemployment, 1931, as Mr. Fairchild proceeds to point out, in Harpers, the one word that is on everybody's tongue is "Overproduction." It is overproduction that is the cause of the business depression, of unemployment—overproduction in industry, in agriculture, in everything. Shades of classical economists! What has become of the elaborate arguments that they were so busy developing a century ago that overproduction is an impossibility?

For untold ages it has been necessary that the vast majority of mankind work long hours each day to exist. The one imperious demand that nature made upon him was work; this was a direct and conspicuous relationship between the amount of work he did and his chance of survival.

Today this no longer is true. Man suddenly has found himself possessed of a productive mechanism so capacious and so competent that if he expends his habitual amount of work on it, it will swamp him with more goods than he has ability to grapple with. The old time mechanic simply cannot compete with the huge and infinitely accurate machines which perform the work of a dozen skilled men. No wonder he stands trembling, awestruck, before his own devices, the use of which defies his intelligence, the power of which far outstrips his ability to control.

The majority of mankind today could be released from overwork, for machinery is fully capable of doing all they ever did and much more, but such is the nature of man that now he cannot stop—he still continues to regard work as a virtue rather than the vice it really is.

And here we may repeat Don Marquis' famous query—

"Have you ever noticed how all philosophies coil up and kick themselves?"

So it seems we will have to develop a new philosophy of leisure time, for we are destined to have much of it.

This does not imply that we will be expected or permitted to spend this leisure time in idleness, for idleness does not contribute to the development of our personalities. We will be expected to engage in pursuits which bring pleasure to ourselves, in the creation of objects which contain the impress of our own personalities. All disagreeable work will be done by machinery operating only in such ways and for such periods as to satisfy the most efficient consumption of the community. And in place of the work inspiring wall mottos which now adorn the walls of our offices and homes we shall have some such as this which was designed by Don Marquis for use in the "Almost Perfect State":

> Heed no maxims, stale and olden,
> That bid you garner worldly spoil!
> Shame upon you for the golden
> Hours you waste in selfish toil!

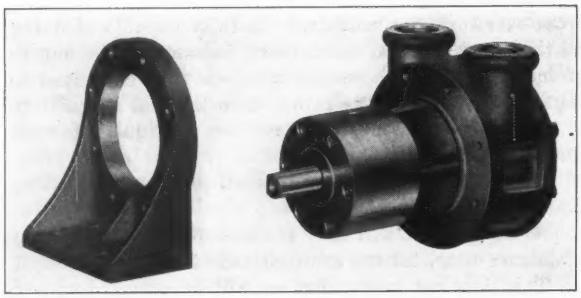
Making a living is something that involves entirely too much trouble and no one should be compelled to do it. We are beginning to realize that there is not enough necessary work to go around and not only must unnecessary work be discouraged, but it must not be permitted unless there is some positive and demonstrable social good to be derived from it. Work is too potent a thing to be indulged in irresponsibly, and in the future the person who insists upon working—in "earning his bread in the sweat of his brow," will be set upon by the minions of the law and clapped into the hoosegow with dispatch as befits any dangerous criminal.

Power Plant Engineering Developments and News

Ball-Bearing Oil Pumps

ANNOUNCEMENT has just been made of the new ball-bearing Model CP oil pumps primarily intended for hydraulic applications but also suitable for handling all lubricating liquids.

The new pumps are of the rotary, internal gear, positive delivery type with improved stuffing-box and the ball-bearing feature incorporated. They are built to handle pressures up to 200 lb. per sq. in. on liquids with fair lubricating qualities. Four sizes are available,



MODEL CP PUMP WITH BRACKET

ranging in capacity from 2 g.p.m. at 300 r.p.m. to 40 g.p.m. at 1200 r.p.m.

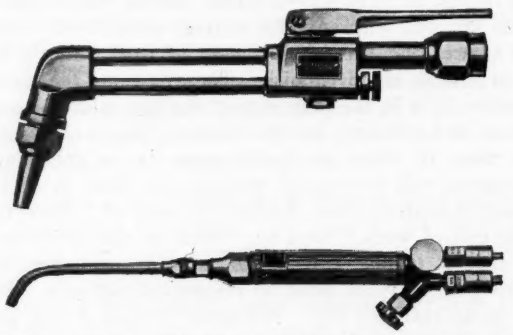
Construction features include ball-bearings to absorb the thrust and radial loads of the rotor, compactness and a new standard mounting design, primarily arranged for end mounting with an optional bracket for users desiring foot type of mounting.

Operating features include development of pressures up to 200 lb. per sq. in.; efficiency in performance claimed to be as high as 70 per cent on good grades of lubricating oil; direct-motor drive at speeds up to 1200 r.p.m.; maintenance of prime by use of upright ports and ability to drive pump in either direction of rotation, suction and discharge ports interchanging when the rotation is reversed. The pump is made by the Tuthill Pump Co., Chicago, Ill. Another new series is the Model L, a rotary pump of the internal gear, positive delivery type including the Tuthill mechanical seal. Six sizes are available ranging in capacity from 3 g.p.h. to 180 g.p.h. Speeds up to 3600 r.p.m. are possible in the smaller pumps and up to 1800 r.p.m. in the larger sizes. Pressures up to 200 lb. per sq. in. can be developed in the larger pumps. These pumps may be mounted above the level of the liquid to be pumped as they have a high suction lift. Model L pumps are designed for oil burning installations of various sizes, for hydraulic applications, and the like.

Attachments for Welding Blowpipe

NEW ACCESSORIES for the Oxweld Type W-17 welding blowpipe, introduced by the Linde Air Products Co., 30 East 42nd St., New York, N. Y., recently, now make this blowpipe capable of doing almost any type of work which may be required of an oxy-acetylene blowpipe.

The Oxweld Type CW-17 cutting attachment enables the blowpipe to do a reasonably wide range of cutting work. This cutting attachment differs radically from any such attachment which has previously been manufactured. It will be noted that a long handle is used for operating the cutting oxygen valve. When this handle is not in use, it can be pulled forward parallel to the tubes so that the whole attachment may be carried around in the operator's pocket. The attachment has



OXWELD CW-17 CUTTING ATTACHMENT (TOP) AND OXWELD W-17 BLOWPIPE HANDLE WITH ADAPTOR AND W-15 WELDING HEAD (BOTTOM) RECENTLY INTRODUCED BY THE LINDE AIR PRODUCTS CO.

the same style stem lock nut as the welding head for the Type W-17 blowpipe. The injector for the heating flames is contained in the attachment, just as the injectors are contained in the welding heads. At the rear of the attachment near the bottom is an adjusting screw, so that the oxygen for the heating flames may be regulated by the operator's thumb and forefinger while the blowpipe is in operation. The attachment is joined to the blowpipe handle in exactly the same manner as a welding head; that is, the lock nut can be tightened by hand and no wrench is necessary to join the attachment to the handle. The attachment is supplied with two cutting nozzles.

Another accessory which has just been introduced for use with the W-17 welding blowpipe is the W-17 to W-15 adaptor which makes it possible to use any of the

welding heads available for the Oxweld W-15 sheet metal welding blowpipe handle. This means that the W-17 welding blowpipe may be used on work ranging from the lightest type of welding to the heavy general welding work required of such equipment. The end of the adaptor which fits onto the W-17 blowpipe handle is similar to the rear end of a W-17 welding head. The adaptor contains passages for the oxygen and acetylene which fit tightly against the passages in the blowpipe handle. The other end of the adaptor is exactly the same as the end of a W-15 sheet metal blowpipe handle, so that no more adjustment is required in attaching the W-15 welding head to the adaptor than to a W-15 handle.

Button Hole Tape for Gaskets

BUTTON HOLE TAPE for Gaskets has recently been placed on the market by The Garlock Packing Co., Palmyra, N. Y. It is made, as shown, of two parallel courses A, Fig. 1, of high grade folded asbestos cloth joined by a single ply of bonding fabric B. As shipped from the factory, it contains no holes.

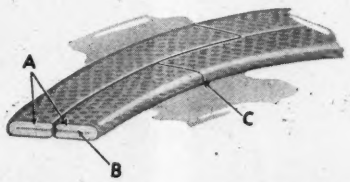


FIG. 1. CONSTRUCTION OF BUTTON HOLE TAPE

Insertion of a knife blade, however, between the two parallel sections of the tape cuts the bonding fabric, forming a button hole that slips over the bolt or stud. No tools other than a knife are required.

Ordinarily the button holes are cut as the tape is applied but to facilitate cutting them before applying, when that is necessary, the tape is printed with one-inch graduations. For joining the two ends a step joint C, Fig. 1, is recommended, wrapped with friction tape, a roll of which is furnished with each box of buttonhole tape. The Garlock 616 Button Hole Tape is made in coils of any desired length and in all regular widths and thicknesses.

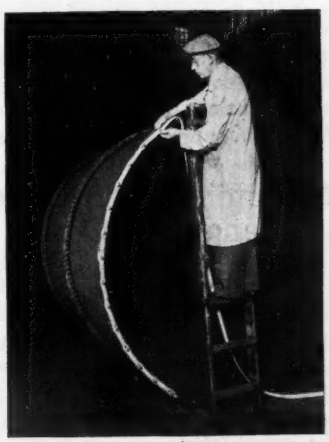


FIG. 2. METHOD OF APPLYING TAPE

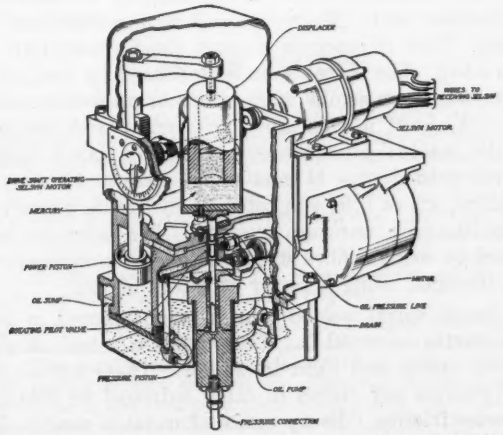
Power Type Pressure Device to Operate Gages

DEAD WEIGHT GAGE TESTER accuracy and permanence of calibration together with unlimited power for the operation of indicators, recorders and control devices, are features of the new Bailey Meter Co., Cleveland, O., power type pressure device. This device is in effect a dead weight gage tester combined with a hydraulic torque amplifier and a Selsyn motor system of long distance transmission.

The power type pressure device, a sectional view of which is shown in the illustration is located near the pressure to be indicated or recorded. This pressure is applied by means of the pressure connection at the bottom of the device to a small pressure piston which supports a pilot valve and a cup containing mercury. This portion of the pressure device, which is continuously rotated to eliminate static friction, is equivalent to a dead weight pressure gage tester, as the applied pressure is counterbalanced by the weight of the rotating parts and mercury plus reaction of the displacer in the mercury. A small motor which rotates the pressure piston pilot valve and mercury cup is also used to drive a small oil pump which provides the oil pressure required for operation of the power piston, displacer and Selsyn motor.

When the applied pressure increases or decreases, the pressure piston rises or falls proportionately, and in so doing permits oil under pressure to pass through the pilot valve to the upper or lower side of the power piston. If the pressure is increasing, the pressure piston, pilot valve and mercury cup move upward, thereby throwing the pilot valve out of its neutral position and applying oil pressure to the upper side of the power piston. This causes the power piston to move downward, forcing the displacer deeper into the mercury. The reaction of the buoyant force of the mercury against the displacer will cause the mercury cup and pilot valve to be forced downward against the increased pressure under the pressure piston.

This downward movement of the mercury cup, pilot valve and pressure piston returns the pilot valve to its neutral position and closes off the oil supply to the power piston; consequently, for each pressure applied



BAILEY METER CO. POWER TYPE PRESSURE UNIT FOR SELSYN OPERATED INDICATORS AND RECORDERS

to the small rotating pressure piston, a definite position of the power piston and displacer is obtained. By driving a Selsyn motor from the rack on the power piston rod, the position of the Selsyn is an accurate indication of the applied pressure. Since the receiving Selsyn indicators and recorders assume the same position as the transmitting Selsyn, it is possible to secure accurate remote indications or records of the desired pressure.

By varying the diameter of the pressure piston, the size of the mercury cup and the size of the displacer, it is not only possible to furnish this power pressure unit for practically any maximum pressure but also for a very large suppression. The indicator similar to a large master pressure gage permits of a total pressure range of only 30 lb. (385 to 415 lb.) for an average operating pressure of 400 lb. Since this type of indicator is 42 in. in diameter, each division, which represents a pound, covers considerable space on the indicating scale. Indicators of this type make ideal master pressure indicators for central station use. The possibility of connecting as many as 12 or more indicators or recorders in the same master pressure circuit, makes this device a desirable means for indicating and recording master steam pressure. The Selsyn motor system of transmission which is employed by this device permits of the installation of master pressure indicators or recorders in the control room on the switchboard without fear of leaks from pressure lines as has been the case heretofore.

If desired, the mercury cup can be designed so that the maximum pressure can be varied within limits by the addition or removal of weights. In this case, the compression is changed but the magnified pressure range remains the same.

Spiral Welded Pipe

SPIRAL WELDED PIPE is the latest development of the American Rolling Mills Co., Middletown, O., Among the favorable features to be found in this new Armco spiral welded pipe are the lighter weight, easier handling, long sections which reduce the number of field joints; smooth inside wall which reduces friction and pumping costs, and a saving in shipping and handling costs. Manufacture of spiral welded pipe is continuous. The long coils of iron or steel strip from the strip mill are placed in a decoiling device on one end of the pipe machine, which is one compact self-contained production unit. There the coil is unwound and flattened. Then it proceeds through the forming rolls and is welded. The spiral seam is produced by feeding the strip into the machine at an angle of approximately 45 deg. A cutoff mechanism synchronized with the speed of the welded pipe assures accurately gaged lengths. Spiral welded pipe is next taken directly to a testing machine where it is subjected to hydraulic pressure at twice the safe working pressure. The latter is determined by using a fibre stress based on the ultimate tensile strength, using a factor of safety of four.

Armco spiral welded pipe is manufactured in jointless lengths up to 40 ft. Every joint is round, straight, smooth inside and light in weight. There are no interior grooves nor ridges to catch sediment or debris, or increase friction. Every ounce of metal is used to form the side walls; there are no projecting bands nor seams to add non-utilized weight. It is easy to weld and can be used with any of the standard couplings. Armco is now supplying this pipe in sizes ranging from 6 to 24 in. in diameter in any wall thickness from 12 gage to ¼ or ⅜ in. It can be furnished with any type of coating desired; mill coat, asphalt inside and out, or galvanized.

New Product for Sealing Brick Boiler Settings

FOR THE SEALING of brick boiler settings, a new product as Dearborn Sealkote has just been placed on the market by the Dearborn Chemical Co., 310 So. Michigan Ave., Chicago, Ill. The infiltration or leakage of air through boiler settings causes serious fuel loss and it is the purpose of Sealkote to seal all cracks in the setting and maintain an airtight condition for an indefinite period.

The outstanding advantage of this product is the complete key or bond to the brick setting which is

BOILER SETTING BEFORE (LEFT) AND AFTER (RIGHT) APPLYING DEARBORN CHEMICAL CO. SEALKOTE

obtained. The coating is applied with a trowel after the brick surface has been thoroughly wet with water. Sealkote, being a water-asphalt emulsion, is carried into the wet surface and fills all cracks or pores; in this way, the perfect sealing effect is obtained.

Sealkote dries rapidly after it is applied and the resulting coating remains firm and at the same time pliable and elastic, therefore sealing subsequent cracks or checks in the setting. Asbestos fiber is incorporated in Sealkote to give additional mechanical strength to the film. A coating thickness of from ⅛ to ¼ in. is recommended. Boiler settings treated in this way can be finished with aluminum bronze paint or colors if desired.

Midwest Bituminous Coal Conference at Urbana, May 21 and 22

SECOND MIDWEST BITUMINOUS COAL CONFERENCE is to be held at the University of Illinois, Urbana, Ill., on May 21 and 22, according to a recent announcement. About 30 program subjects which refer particularly to utilization and performance of coal in power, industrial and domestic fields have been discussed by the program committee and further details of the program to be presented will be issued later.

According to B. R. Gebhart, Illinois Coal Bureau, 307 N. Michigan Ave., Chicago, Ill., chairman of the program committee, the tentative program already arranged includes on Thursday, May 21, an inspection of engineering buildings and laboratories, geological surveying exhibits and mining engineering laboratory at 10:30 a. m., the opening session at 1:30 p. m., informal dinner at 6:00 p. m. and technical session at 7:30 p. m. On Friday, May 22, a general session will be held at 9:30 a. m. and another at 1:30 p. m. Prof. A. C. Callen is chairman of the local arrangement committee at the University of Illinois, Urbana, Ill., while Dr. M. M. Leighton, Illinois State Geological Survey, Urbana, is chairman of the publicity committee. Further details of the meeting can be obtained from the foregoing chairmen.

Death of Lieutenant General Edgar Jadwin

On March 2, Lieutenant General Edgar Jadwin, retired chief of the army engineers, died at the Gorgas Hospital, Panama City, after a cerebral hemorrhage. General Jadwin was known most widely for his work in connection with the rivers and harbors of the United States. He went to Panama City on February 25 to head a committee appointed to determine whether a new interoceanic canal is needed in Nicaragua or whether the Panama Canal should be provided with new locks.

He was 65 yr. old and was a native of Honesdale, Pa. He was graduated from West Point in 1890, entered the engineering corps and became a lieutenant general upon his retirement in 1929.

In July, 1930, General Jadwin was called from retirement by President Hoover to become chairman of the newly created federal power commission that superseded the former organization of various cabinet officers.

During the world war, General Jadwin organized and commanded the Fifteenth Engineers and in France was director of light railways and roads for the A.E.F. and later director of construction and forestry. He was awarded the distinguished Service Medal by the United States, was made a Companion of the Bath by Great Britain and a commander of the Legion of Honor by France. One of the projects with which he was most intimately concerned was the Jadwin plan for control of the Mississippi River.

Illinois Utilities Discuss Home and Farm Service

Nearly 1000 representatives of the utilities organizations of Illinois attended the annual conventions of the Illinois Electric, Illinois Gas and Illinois Electric Railways Associations in Springfield, Ill., March 12—14, at which A. D. Mackie, Springfield, vice president and general manager of the Illinois Power Co., was elected president of the electric group; R. B. McDonald, Moline, Peoples Power Co., president of the electric railways group; and H. E. Kleinman, Moline, head of the gas association. George W. Schwaner, Springfield, was reelected secretary-treasurer of the three organizations.

Harland A. Allen, economist of the Foreman-State National Bank, Chicago, addressing the annual banquet upon "Working Back to Normalcy," predicted that with the return to normalcy, the electric industry, which he described as "yet in its primitive stage" would go farther in general expansion and prosperity than ever before in its history.

"A big possibility to develop home lighting in Illinois," was foreseen by Oliver R. Hogue, retiring president of the electrical association. Charles W. Hadley, chairman of the Illinois commerce commission, pointed out the value of the commission in eliminating competition among utility concerns.

Leslie Vickers, who discussed electric transportation, declared there is no reason for pessimism in that field, except in isolated spots. A survey in New York City, he related, had revealed that 150 cars, passing an average spot, carried an average equal to 60 passengers, as many as 5600 automobiles could carry at the same period. He said the electric railway handles mass traffic better than any other agency and by this service, alone, makes its continued existence certain.

Development of electric and gas service on farms is still in its earliest stages, speakers at the rural power conference admitted; they united in urging further study and development of service extensions. "With the combined business ability that the gigantic electric interests represent, the utilities, it seems, are lacking in an understanding of the electrical requirements of the agricultural industry," Stuart E. Pierson, director of the state department of agriculture, declared.

J. H. Mathews, chief engineer of the commerce commission, declared that rural residents should have the same utility privileges as city residents, even though returns to the utilities from that source should not at first yield a proper return upon the necessary investment. The conference, he said, should aim to "persuade indifferent utilities to become more active in rendering electric service; standardize rates and policies; simplify preliminary investigations before rendering service and expedite connections; develop some plan for taking care of the tenant and poorer classes of farmers; convince utilities not to expect an attractive return on all rural business during its development stage, since prudent extension of lines into promising districts, even though a profit cannot be expected for some time to come, would be a most effective educational campaign; and farmers should forget all neighborhood troubles and aid neighbors in getting electric service though they may have to carry a heavier financial burden than the neighbors, as added service on a line will eventually cheapen and improve service."

News Notes

Northern Equipment Co., Erie, Pa. announces the appointment of Joseph W. Eshelman, 1220 Webb-Crawford Bldg., Birmingham, Ala. as its representative in the Alabama territory. The company also announces the appointment of the Economy Equipment Co., 301 Buder Bldg., St. Louis, Mo. as its representative in the St. Louis territory. Another appointment of the company is that of Bell & Eiss, Inc., 459 N. W. National Life Bldg., Minneapolis, Minn. as its representative. E. F. Bell has been manager since December, 1928, of the H. J. Meier Co., former representative of the Northern Equipment Co. in Minneapolis, and Mr. Eiss has been associated with him for about two years.

Champion Machine & Forging Co., Cleveland, Ohio, has recently installed a new 1000-hp. boiler plant to serve its forging shop. The installation consists of a water-tube boiler of 10,000-sq. ft. heating surface, designed for continuous operation at 300 per cent rating and fired by a 10-retort, 25-tuyere rotary ash discharge Taylor stoker. The boiler was built by the D. Connelly Boiler Co. The back wall of the furnace is water-cooled and front and side walls are aircooled.

On the operating floor between boiler outlet and induced draft fan, a Foster Wheeler economizer reduces the flue gas temperature from about 600 deg. to about 350 deg. F., raising the temperature of the feedwater about 100 deg.

Coal is sent to the stokers from a cylindrical reënforced concrete silo with a capacity of 950 t. Coal from the track hopper is elevated to the silo by a 35-t. per hr. bucket elevator.

"Under normal operating conditions," says J. Fred Connelly, vice president of the company, "a fuel saving of 100 t. of coal per week is expected by operation of the new unit. A saving is also made by ability to use a different grade of coal. The old and new units give us a combined maximum capacity of 4650 hp."

The new boiler plant was designed by W. C. Kammerer of Hadlow, Hughes, Hick & Conrad, engineers and architects of Cleveland.

HENRY C. GRATON, a founder of the Graton & Knight Mfg. Co., Worcester, Mass., died in that city on March 20. He was 100 yr. old and for 50 yr. had been a prominent factor in the management of the company. He was born in Leicester, Mass. and when he was 21 yr. old formed a partnership with Joseph A. Knight. In 1867 the firm established its own tannery in order to control the manufacture of leather and to improve the quality of goods it was manufacturing. In 1872, the Graton & Knight Mfg. Co., which is now the Graton & Knight Co., was incorporated and Mr. Graton became its treasurer, which post he held until he was over 90 yr. old.

H. W. FULLER, vice president in charge of engineering and construction, Byllesby Engineering and Management Corp., Chicago, Ill., presided at the sixth annual convention of the company's engineering department held March 24 and 25 in the Bal Tabarin of the Hotel Sherman in Chicago. Many papers were presented covering the various phases of the company's engineering and construction operations. At the annual convention dinner held Wednesday evening, March 25, the principal speakers were G. E. Mason, Chicago attorney, who gave some "Observations of a Traveler in Russia," and E. L. Manning of the research branch, General Electric Co., Schenectady, N. Y., spoke on "Gulliver's Travels Among the Real Lilliputians of the Universe."

GENERAL REFRACTORIES Co., Philadelphia, Pa., has recently appointed the Davis Coal and Supply Co. of Reading, Pa., as distributors of its products for Schuylkill, Berks, Lebanon counties and the northern part of Lancaster county.

F. C. THOMPSON, vice-president and general manager of the Morse Chain Co., Ithaca, N. Y., announces the appointment of Walter W. Bertram as sales manager of the Industrial Chain Division. Mr. Bertram, who has been with the Morse Chain Co. for 18 yr. and has been manager of the New York office for the past 8 yr. Mr. Thompson also announces the appointment of A. B. Wray, former sales manager, to the position of chief engineer in charge of all industrial chain engineering.

LINCOLN ELECTRIC Co. has removed its Chicago office from 53 W. Jackson Blvd. to 1455 W. 37th St.

FOSTER WHEELER CORP. of New York City announces that it has entered the field of boiler manufacture and is prepared to furnish all types in the entire range of sizes and pressures. For this purpose, it has recently acquired the plant and business of the D. Connelly Boiler Co. of Cleveland, Ohio. With the addition of the boiler to its products, the Foster Wheeler Corp. states that it is now prepared to undertake single contracts with undivided responsibility as to design, construction and operation for complete steam generating units, including pulverized fuel equipment, water-cooled furnaces, superheaters, economizers and air heaters. It is also expected that the addition of the boiler shop fully equipped for heavy work will be of great advantage in meeting requirements for heater and evaporator shells for fractionating and stabilizer towers and other petroleum refining and gasoline recovery equipment. Steam generating units to be produced include: forged-steel, sectional-header, cross-drum boilers; four-drum and three-drum bent-tube boilers; three-drum low-head bent tube and two-drum bent-tube boilers. For marine service that will be offered, as in the past, cross-drum steam generators, both box header and sectional header designs, three-drum A type and two-drum low-head units.

ARNOLD STUART DURRANT, for the past six years vice-president in charge of commercial relations of the International General Electric Co., Inc., retired from active service on March 1 and was made an honorary vice-president of the company, following a connection of 40 yr. with the General Electric organization.

IN THE EARLY PART of 1931, E. H. Bolton, 549 W. Randolph St., Chicago, Ill., became the representative of the Flexitallic Gasket Co., Camden, N. J. in the Chicago district.

ALCO PRODUCTS, INC., division of the American Locomotive Co., announces the opening of branch offices in the Esperson Building, Houston, Texas, and in the Philtower Building, Tulsa, Oklahoma. R. H. Brinton will represent the company at Houston and T. B. Leech at Tulsa, as sales engineers. The company also has announced the appointment of John H. Smith as chief engineer of the surface condensers department. Mr. Smith brings to his new post more than 16 yr. of experience in the engineering and sale of steam condensers and their important auxiliaries. Condensers designed and built according to Smith patents are in service in many large power stations in this country, it is stated, and include sizes ranging up to 90,000 sq. ft. of condensing surface. T. A. Burdick has joined the staff of the company as chief designing engineer for power plant equipment. Mr. Burdick brings to his new post more than 12 yr. of experience as a designer and construction supervisor of power installations in various parts of the country.

MECHANICAL HANDLING of materials will be shown in an exhibit planned for Nov. 30 to Dec. 5, 1931, in the Grand Central Palace, New York. It will be arranged by the International Exposition Co. of the same address, of which Charles F. Roth is manager.

W. M. WILLETT and C. H. Kallstedt were made vice presidents of the Western United Gas and Electric Co. at the directors' meeting in Aurora, Ill., recently at which other officers of the utilities corporation were reëlected. Samuel Insull, Chicago, is chairman of the board; Samuel Insull, Jr., vice chairman; George R. Jones, Chicago, president; Benjamin P. Alschuler, John Egolf, W. M. Willett, and C. H. Kallstedt, all of Aurora, vice presidents; Murray D. Smith, Aurora, secretary-treasurer; J. T. Parsons, Aurora, assistant secretary-treasurer. Mr. Willett has been associated with the company since 1896 and since 1918 has been general manager of the company. Mr. Kallstedt has been service manager for the Public Service Co. of Northern Illinois in Evanston since 1928.

ANNUAL MEETINGS of the Illinois Power Co. and the Illinois Power Building Corp. reëlected directors and officers in Springfield, Ill. March 13 and A. D. Mackie, vice president and general manager reported gross earnings for 1930 at $2,914,617, an increase of 6.5 per cent over 1929. Operating expenses and taxes were $1,788,288; fixed charges $368,897; depreciation, $150,000 and dividend on preferred stock, $242,246, leaving a balance of $365,185, $65,000 greater than 1929. The company spent $728,892 on additions and improvements in the Springfield, DeKalb and Sycamore territories. Electric sales increased 12.1 per cent and were three times as great as in 1920. Gas sales increased three per cent over 1929 but street car revenues fell off 9 per cent.

APPLICATION has been made by Columbia River Power Co. of Seattle, Wash., to the Federal Power Commission for permit to develop 250,000 hp. on the Columbia River near Cascade Locks, Ore., with units of 30,000 to 40,000 Hp. Estimated cost of the project is $20,000,000.

GEARS AND FORGINGS, INC. of Cleveland, Ohio, announces the appointment of George H. Davis to the Pittsburgh District Sales Office, 2818 Smallman St., Pittsburgh, Pa. Mr. Davis was transferred from the company's Milwaukee office and will be in charge of the Pittsburgh territory.

CONCO CRANE & ENGINEERING WORKS, division of H. D. Conkey & Co., Mendota, Ill., has appointed C. P. Maxson, Auditorium Garage Bldg., Cleveland, Ohio as its new representative in that territory. It has also appointed Starr-Carpenter, Parks Bldg., Pittsburgh, Pa., as its representative.

FAIRFIELD ENGINEERING Co., Marion, Ohio, announces the appointment of H. J. Burckart as its Chicago representative. He is located at 1922 Transportation Bldg., 608 South Dearborn St., Chicago, Ill.

AT THE RECENT annual meeting of the Board of Directors of the San Antonio Public Service Co., San Antonio, Texas, W. B. Tuttle was reëlected president for 1931. Other officers elected were E. H. Kifer, vice-president and general manager; James Lawrence, vice president; R. C. Jones, treasurer.

HARRY P. READMON, purchasing agent of the Chicago Pneumatic Tool Co. of New York for the past 12 yr., died on February 26.

PLIBRICO JOINTLESS FIREBRICK Co., Chicago, Ill., announces the appointment of John J. Bower Jr. as direct factory representative for the Richmond, Va. territory.

HEATING DIVISION of The Wickes Boiler Co., Saginaw, Mich., announces the appointment of the Kilner-Mills Co., 3-266 General Motors Bldg., Detroit, Mich., as its district representatives for L-O steel heating boilers.

FRANK R. PHILLIPS, senior vice president of the Philadelphia Co. and subsidiary companies, has announced the appointment of Joseph McKinley as acting vice president in charge of sales and service. Mr. McKinley succeeds George E. Whitwell who has accepted a position with the Philadelphia Electric Co., Philadelphia, as vice president in charge of sales. Mr. McKinley was born on May 31, 1877 in Pittsburgh, Pennsylvania. He received his education in Pittsburgh public and high schools, following which he entered Pennsylvania State College and was graduated from that institution in the class of 1900 in electrical engineering. Following

his graduation he entered the employ of the Westinghouse Electric and Manufacturing Co. In 1903 he entered the employ of the Allegheny County Light Co., now the Duquesne Light Co. He was the first power salesman for the company and later served as manager of power sales, general contracting agent, manager of the wholesale sales and service department of the Duquesne Light Co. and Equitable Gas Co. Mr. McKinley is a member of the Keystone Athletic Club, Pittsburgh Chamber of Commerce, Engineers Society of Western Pennsylvania, Association of Iron and Steel Electrical Engineers, National Electric Light Association, American Gas Association, and the Electric League of Pittsburgh.

J. F. McLAUGHLIN, who was assistant to A. F. Townsend, when the latter was manager of the Stone & Webster interests at Beaumont, Tex., has been made president of the Puget Sound Power Co. at Seattle, Wash., according to a recent announcement. Mr. McLaughlin has been vice-president of the Stone & Webster Service Corp. with headquarters at Boston, Mass.

AFTER 17 YR. service with Stone & Webster, Inc., spent in various properties and almost seven years with Gulf States Utilities Co. as superintendent of production, Harry Sharpless joined the Gulf Refining Co. at Port Arthur, Texas, recently as superintendent of power, having charge of all steam and electric plants of the huge refinery. Mr. Sharpless joined Stone & Webster in 1913 as student engineer at Tampa. From there he was in successive steps, assistant chief engineer of the Blackstone Valley Gas & Electric Co. in Rhode Island, chief engineer of the Baton Rouge Elec. Co. and chief engineer of the Pensacola Elec. Co. from which job he came to Port Arthur.

ASHTON VALVE Co., Cambridge, Boston, Mass., announces the election of Henry B. Nickerson as vice-president in charge of sales. Mr. Nickerson until his election as above noted was vice-president of the Consolidated Ashcroft Hancock Co. and prior thereto with the American Schaeffer & Budenberg Corp. and the American Steam Gage and Valve Mfg. Co. Mr. Nickerson assumed his new duties March 16 and will be located at the main office, 161-179 First St., Cambridge, Boston, Mass.

ANNUAL MEETING of the American Welding Society will be held at the Engineering Society Bldg., 29 W. 39th St., New York City, on April 22, 23 and 24.

Business sessions, annual dinner, technical sessions and inspection trips are scheduled. Technical sessions include important papers on ship construction, papers and code on welded piping, resistance welding, structural steel welding, research reports, alloy steel welding, thermit welding and numerous other subjects. Complete details of the program and arrangement for the meeting can be obtained from the secretary of the society at the above address.

Books and Catalogs

TREATISE ON LEATHER BELTING, by George B. Haven and George Swett; 250 pages, 5 by 8 in., fully illustrated and with thumb index, cloth, 1930; price, $1.50.

Just published, after 2 yr. spent in compilation from data furnished by the principal makers of belting in the country and by researches at Mellon Institute and Cornell University, this book, prepared by two members of the faculty of Massachusetts Institute of Technology includes the latest and most reliable data on belt engineering as well as the best information on leather manufacture, qualities of leather and how to get the right belt for any requirements.

Although the American Leather Belting Association sponsored the work and assisted in gathering data, the authors were given a free hand in choosing, compiling and writing to give an unbiased and scientifically correct presentation of the subject. The ground covered is indicated by the chapter headings: I. Leather Manufacture; II. Physical Properties of Belting Leather; III. Methods of Manufacture of Leather Belting; IV. Belting Practice; V. Installation and Care of Leather Belting; VI. Leather Belts on Motor Installations; VII. Belt Drive Engineering; VIII. Belt Research; IX. Specifications and Inspection; X. Tables, Nomographs and Plots.

Four groups of users were kept in mind in preparation of the book: Those who purchase belting and need an intelligent idea of what they are buying, with the necessary specifications and inspection to secure the required quality of material; those who have charge of installation and care of belts; engineers who must determine sizes, qualities, speeds and the like for given drives; students and engineers who need a treatise on belting and belt requirements as a book of reference and information.

With these ends in view, leather is followed from the raw hide to the finished belt and the effects of different treatments given. Grades and weights of belting are given, the right pulleys to use and why, tables of power and belt speeds, use of idlers, short center drives and rules for application of belts to machines.

Installation of belts, including the various joints, lining up, taking up slack; also care such as repairing and cleaning are fully considered. Relative advantages and costs of individual and group motor drives with tables are given.

Belt engineering is clarified and simplified by the use of numerous tables and charts, giving the accuracy required for mill engineering. Trigonometric tables are arranged by degrees and decimal fractions, as it was thought to be more convenient than the old form of minutes and seconds and facilitates computations.

This book is a valuable contribution to available data on power transmission, making available much data heretofore in possession only of belting manufacturers and giving authoritative, reliable methods for conveniently proportioning belt and pulley drives on a conservative basis.

CAMPBELL FEED WATER REGULATOR is described in a new 16-page bulletin issued by Atlas Valve Co., 282 South St., Newark, N. J. The principle of the regulator is discussed, details are given of its connection and operation under various conditions, also directions for installation, length of sampling pipe, arrangement of bypass and similar items. A complete list of parts with prices is included, also a complete list of control valves of various designs, illustrated and with price list.

NEW PUBLICATION covering industrial heating equipment has recently been issued by Westinghouse Elec. & Mfg. Co., E. Pittsburgh, Pa. In this 100-page bulletin are operating data, charts, tables and installation photographs, besides specifications and illustrations of industrial heating equipment. Definitions of terms, tables for furnace sizes and operating costs, descriptions of installations and specification for heating appliances are also given. Control equipment is described in detail.

FULLER-KINYON system for pulverized coal is described and illustrated in detail in a recent 8-page bulletin by Fuller Lehigh Co., 85 Liberty St., New York. Details are given of the application of the system, construction and operation of the Fuller-Kinyon pump and electro pneumatic valves for controlling flow through the pipe lines, also of the bin-level indicators and methods for controlling the entire system from a central board.

FILTICOOLER for washing, filtering and cooling air is described in catalog No. 378, recently issued by B. F. Sturtevant Co., Hyde Park, Boston, Mass. This device is described in detail with illustrations and tables of capacity, resistance to air flow, weather temperatures and so on.

ROSSMAN SYSTEM of adjustable speed control is described in detail with discussion of the principle of operation, diagrams and photographs of the control and methods of calculating sizes in bulletin 1151 just issued by Allis-Chalmers Mfg. Co., Milwaukee, Wis.

BLEEDER LINE PROTECTING VALVES for use in the extraction line leading from bleeder turbine to boiler feedwater heaters are described in a new bulletin No. 8K by Schutte & Koerting Co., Philadelphia, Pa. Details of the construction of the valve, tables of pressures, dimensions and prices and engineering data on their application are given in the bulletin.

BROWN ELECTRIC CO_2 METERS, indicating and recording types, are described and illustrated in Catalog No. 3004, just issued by the Brown Instrument Co., Philadelphia, Pa. The bulletin first discusses how waste occurs in combustion, how CO_2 meter indicates losses, the thermal-conductivity principle applied to CO_2 measurement, detection of free hydrogen in flue gas and gives a detailed description of the meter, its various parts and the methods of using it.

ETTCO HIGH-SPEED TAPPING ATTACHMENT with Ettco visible-grip, tap-holding chuck is described in recent folder by the Strong, Carlisle & Hammond Co., 1392 West Third St., Cleveland, Ohio.

NEW MARLEY SPRAY DECK COOLING TOWER is described in bulletin No. 30 just issued by the Marley Co., Kansas City, Mo. This discusses spray distribution, Marley spray nozzle, maximum cooling efficiency, construction of the louvre with controlled air distribution, application of spray and Marley deck design, with many illustrations of installations.

FLOW CONTROLLERS are discussed in bulletin No. 170 just issued by the Foxboro Co., Foxboro, Mass. Applications of flow controllers are first described with discussion on the need for them and advantages of their use; then the principle of the Foxboro flow controller is discussed in detail with diagrams and illustrations of the controller and its various parts. Diagrams of hook-ups showing the device in use for controlling liquid and gases, use of the ratio flow controller and flow controllers for high pressures are other subjects discussed, with many illustrations of application and of the equipment itself.

STEAM TURBINES, principles of operation and details of parts, governing, generator and general considerations of use are described in a recent bulletin, No. GEA 1011B, by General Electric Co., Schenectady, N. Y.

Power Plant Construction News

Ala., Birmingham—The Dr. Pepper Bottling Co., 2805 Second Avenue, Birmingham, plans installation of electric motors and other power equipment in new three-story and basement soft drink bottling plant at Avenue B and Twenty-ninth Street, entire project reported to cost over $80,000. D. O. Whilldin, 517 North Twenty-fifth Street, Birmingham, is architect.

Ala., Cottonwood—The Rambo Lumber Co., Cottonwood, is said to be planning installation of motors and other electric power equipment in connection with proposed rebuilding of mill, destroyed by fire, March 24, with loss reported over $100,000.

Calif., Los Angeles—The Fields Chemical Corporation, Financial Center Building, plans installation of electric power equipment in a new metallurgical coke plant, entire project reported to cost over $100,000.

Colo., Grand Junction—The City Council, Grand Junction, is said to be arranging to circulate a new petition for approval of citizens for a municipal electric power plant to cost about $750,000. Plans are nearing completion at the office of Wood & Weber, 810 Fourteenth Street, Denver, Colo., consulting engineers, in charge.

Conn., Bristol—The Connecticut Light & Power Co., Hartford, Conn., is completing plans for its proposed new steam power plant for central heating service on Riverside Avenue, Bristol, to cost more than $100,000, with machinery; boiler installation will be designed to use oil as fuel. Harold A. Hayden, Bristol, is architect.

Fla., St. Petersburg—The New Home Ice Co., St. Petersburg, has acquired a building at Second Avenue and Sixteenth Street, and will remodel and equip for an ice-manufacturing plant. Work will be placed under way at an early date.

Kan., Coffeyville—The North American Car Co. plans installation of electric motors and other power equipment in connection with proposed rebuilding of portion of plant destroyed by fire, March 27, with loss reported over $150,000.

La., Shreveport—The Arkansas Natural Gas Co., Shreveport, plans installation of pumping machinery and other power equipment in connection with a proposed new oil pipe line from the East Texas oilfields to Shreveport and vicinity, totaling about 75 miles, entire project to cost close to $1,000,000. Company operates the Louisiana Oil Refining Co., Shreveport.

Mass., Boston—The Boston Consolidated Gas Co., 100 Arlington Street, has purchased property at Jamaica Plain, providing a total tract of 106,620 sq. ft., and will build a new equipment service and repair plant at that location, reported to cost over $75,000.

Mich., Detroit—The Bon Dee Golf Ball Co., 5626 McGraw Avenue, plans installation of motors and other electric power equipment in connection with proposed rebuilding of portion of plant recently destroyed by fire with loss reported over $80,000. Stanley B. Nicholas is treasurer.

Mich., Ferrysburg—The Construction Materials Corporation, 33 North La Salle Street, Chicago, Ill., plans installation of power and mechanical equipment; distributing and loading machinery, etc., in connection with an expansion and improvement program at sand and gravel plant at Ferrysburg, entire project to cost over $500,000. Company engineering department is in charge.

Minn., Cook—The Arrowhead Light & Power Co., Cook, is reported considering extensions in steam-operated electric light and power plant, including installation of additional equipment. Company also contemplates extensions in transmission lines for service at Leander, Angora and vicinity.

Miss., Hattiesburg—The Crystal Ice Co., care of L. E. Lokey, Gadsden, Ala., is said to be planning a new one-story ice-manufacturing plant at Hardy and Eleventh Streets, with initial capacity of about 20 tons per day.

Mo., Perryville—The City Council, Perryville, has tentative plans under way for a municipal electric light and power plant. Estimated cost has not been announced. Russell & Axon, 6200 Easton Avenue, St. Louis, Mo., are consulting engineers.

Nev., Las Vegas—The Union Pacific Railroad Co., Omaha, Neb., is planning a new steam-operated electric power plant at Las Vegas, with initial capacity of 1500 kva., estimated to cost close to $80,000. An overhead traveling crane will be installed. Company engineering department is in charge.

N. J., Newark—The Art Metal Works, Inc., Mulberry Street, plans installation of motors and other electric power equipment in new multi-story addition, including improvements in present factory, entire project to cost over $150,000. Henry Baechlin, 665 Broad Street, is architect.

N. Y., Elmira—The City Council, Elmira, plans installation of pumping machinery and auxiliary equipment in connection with a proposed sewage disposal plant and extensions in sewage system, for which a bond issue of $1,000,000, is being arranged. City engineering department will be in charge.

Ohio, Hollidays Cove—The Standard Slag Co., Youngstown, Ohio, plans installation of electric power equipment in proposed new slag grinding plant at Hollidays Cove, entire project to cost about $40,000. Company engineering department is in charge.

Ohio, Springfield—The Crowell Publishing Co., Springfield, plans installation of electric power equipment in proposed multi-story addition to printing and publishing plant, entire project to cost over $500,000.

Ohio, Zanesville—The Muskingum Valley Fertilizer Co., Zanesville, is said to be planning the installation of electric motors and other power equipment in connection with proposed rebuilding of portion of plant recently destroyed by fire with loss of about $40,000.

Okla., Shawnee—E. A. Liebman, 1214 West Eighteenth Street, Oklahoma City, Okla., and associates are said to be planning early construction of a new ice-manufacturing plant at Shawnee, to cost over $75,000, with equipment.

Pa., McKeesport—The Standard Oil Co. of Pennsylvania, Ledger Building, Philadelphia, Pa., plans installation of pumping equipment, storage tanks and other mechanical equipment in proposed new oil storage and distributing plant at McKeesport, entire project to cost about $100,000.

Tenn., Memphis—The Board of Works, Memphis, is said to be planning call for bids in June for pumping and other equipment for an auxiliary water plant, consisting of three one-story buildings, reported to cost over $200,000. Fuller & McClintock, 170 Broadway, New York, are consulting engineers.

Texas, Douglass—The Texas Co., Texas Building, Houston, Texas, plans construction of a new pumping plant at Douglass in connection with a pipe line to be installed from Joinerville to this place, for oil transmission. Company engineering department is in charge.

Texas, El Paso—The Nichols Copper Co., 40 Wall Street, New York, plans installation of electric power equipment in proposed new copper wire and rod mill in vicinity of its refining plant at El Paso, entire project to cost over $1,000,000. Company engineering department will be in charge.

Texas, Longview—The Slack Petroleum Co., Tulsa, Okla., plans installation of power equipment in a proposed new oil refining plant at Longview, entire project to cost over $100,000. A boiler house will be built.

Texas, Palestine—The Thrift Packing Co., 3914 Pacific Street, Dallas, Texas, plans installation of electric power equipment in proposed new canning plant at Palestine, entire project to cost over $65,000. J. A. Gage is head.

Texas, Texas City—The Republic Oil & Refining Co., Houston, Texas, will install power equipment in its proposed new oil refinery at Texas City, entire project to cost over $750,000. A boiler plant will be built. Company engineering department is in charge.

Wash., Elma—The City Council, Elma, is said to be planning the installation of a municipal electric light and power plant, using a Diesel engine unit, to cost about $85,000. A distributing system will also be installed.

Wash., Seattle—The Tea Garden Products Co., 755 Sansom Street, San Francisco, Calif., plans installation of electric power equipment in new three-story food products plant, 90x132 ft., at Seattle, entire project estimated to cost over $200,000. The Austin Co., Seattle, is architect and engineer. F. J. Jost is president.